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THIRTY-THIRD ANNUAL REPORT

of

Forage Research

in the

Northeastern United States

1969

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1969

Thirty-Third Annual Report
of
Forage Research
in the
Northeastern United States

A Joint Contribution of the
United States Regional Pasture Research Laboratory
and the
Agricultural Experiment Stations of the 12 Northeastern States

Contributing Agencies

Forage and Range Research Branch, Crops Research Division
Northeast Branch, Soil and Water Conservation Research Division
Grain and Forage Insects Research Branch, Entomology Research Division
Agricultural Research Service, United States Department of Agriculture

The Agricultural Experiment Stations of

Connecticut

New Jersey

Delaware

New York

Maine

Pennsylvania

Maryland

Rhode Island

Massachusetts

Vermont

New Hampshire

West Virginia

* * * * *
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 * crop research workers in the region. Copies are sent *
 * to all organizations involved in the forage research *
 * program of the 12 Northeastern States, to all investi- *
 * gators in the Northeast Region and to some interested *
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 * Pasture Research Laboratory, University Park, Pennsyl- *
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R. B. Alderfer	- New Jersey	W. G. Colby	- Massachusetts
D. W. Allinson	- Connecticut	B. W. Henderson, Jr.	- Rhode Island
C. S. Brown	- Maine	G. A. Jung	- West Virginia
G. L. Byers	- New Hampshire	C. C. Lowe	- New York
N. A. Clark	- Maryland	W. H. Mitchell	- Delaware
R. W. Cleveland	- Pennsylvania	G. M. Wood	- Vermont

W. I. Thomas - Representative of Northeastern Directors

This Annual Report is intended primarily for use by forage research workers in the Northeastern United States. It contains brief reports of research projects carried on at the Pasture Laboratory and most of the State Agricultural Experiment Stations in the region as well as reports from several Regional Project Technical Committees. Thanks are extended to all contributors and to the person at each station who collected the reports.

There are no changes to report in the Collaborator ranks. Dr. Walter I. Thomas was named to replace the retired Dr. M. A. Farrell as the Northeastern Station Directors' representative to the Laboratory. Dean Russell E. Larson is now the Director of the Pennsylvania Agricultural Experiment Station.

Research Scientists, Joseph T. Sullivan, Robert R. Robinson, Vance G. Sprague and Richard C. Newton retired from the Pasture Laboratory staff as of November, and new staff members are expected to arrive in early summer. A conference of Collaborators convened at the Laboratory in May and all states were represented. A program on the genetics of alfalfa and grasses was led by Drs. R. R. Hill, Jr. and C. C. Berg.

The new addition to the Laboratory is complete and the new space is being occupied.

K. T. Leath, Acting Director
U.S. Regional Pasture Research
Laboratory

Roster of Research Workers in the Northeastern United States

Alderfer, R. B.	Soil-Plant-Water Relations	New Jersey
Allinson, D. W.	Forage Management	Connecticut
Anderson, G. C.	Animal Nutrition	West Virginia
Anderson, R. E.	Genetics and Breeding	Cornell
Apgar, W. P.	Forage Utilization	Maine
Barr, W. L.	Farm Management	Pennsylvania
Bartlett, R. J.	Soil Science	Vermont
Baumgardt, B. R.	Animal Nutrition	Pennsylvania
Bennett, O. L.	Forage Management	West Virginia
Benoit, G. R.	Soil Physics	Vermont
Berg, C. C.	Genetics (Grasses)	Pasture Laboratory
Bloom, J. R.	Nematode Control	Pennsylvania
Bornstein, J.	Agricultural Engineering	Vermont
Bratzler, J. W.	Animal Nutrition	Pennsylvania
Braverman, S. W.	Plant Pathology	Geneva
Brown, C. S.	Forage Management	Maine
Burt, G. W.	Weed Control	Maryland
Byers, G. L.	Agricultural Engineering	New Hampshire
Campbell, J. K.	Agricultural Engineering	Cornell
Clark, N. A.	Forage Management	Maryland
Cleveland, R. W.	Genetics and Breeding	Pennsylvania
Colby, W. G.	Forage Management	Massachusetts
Colovos, N. F.	Animal Nutrition	New Hampshire
Connell, W. A.	Insect and Mite Control	Delaware
Crittenden, W. H.	Legume Diseases	Delaware
Decker, A. M.	Forage Management	Maryland
Dickey, H. C.	Forage Preservation	Maine
Dolan, D. D.	Plant Introduction	Geneva
Dorsey, C. K.	Entomology	West Virginia
Downs, W. G.	Forage Management	Pennsylvania
Drake, Mack	Forage Management	Massachusetts
Duke, W. B.	Weed Control	Cornell
Dunn, G. M.	Genetics	New Hampshire
Elliott, E. S.	Root Diseases	West Virginia
Evans, J. L.	Nutritional Value	New Jersey
Fenner, H.	Animal Nutrition	Massachusetts
Flanagan, T. R.	Weed Control	Vermont
Flannery, R. L.	Soil Fertility	New Jersey
Fowler, R. E.	Beef Cattle Nutrition	Delaware

Gross, C. F.	Soil Fertility	Pasture Laboratory
Gyrisco, G. G.	Entomology	Cornell
Haenlein, G. F. W.	Nutritive Evaluation	Delaware
Halisky, P. M.	Plant Pathology	New Jersey
Harris, W. L.	Agricultural Engineering	Maryland
Hemken, R. W.	Dairy Science	Maryland
Henderson, B. W., Jr.	Animal Nutrition	Rhode Island
Hershberger, T. V.	Animal Nutrition	Pennsylvania
Hill, R. R., Jr.	Genetics (Alfalfa)	Pasture Laboratory
Holter, J. B.	Animal Nutrition	New Hampshire
Horvath, D. J.	Animal Nutrition	West Virginia
Howard, F. L.	Pathology, Entomology	Rhode Island
Hower, A. A., Jr.	Forage Insects	Pennsylvania
Ilnicki, R. D.	Weed Control	New Jersey
Jung, G. A.	Plant Physiology	West Virginia
Kardos, L. T.	Soil Physics	Pennsylvania
Keefer, R. F.	Soil Fertility	West Virginia
Kesler, E. M.	Dairy Science	Pennsylvania
Kjelgaard, W. L.	Agricultural Engineering	Pennsylvania
Kradel, D. C.	Veterinary Medicine	Pennsylvania
Leath, K. T.	Pathology (Legumes)	Pasture Laboratory
Linscott, D. L.	Weed Control	Cornell
Long, T. A.	Animal Nutrition	Pennsylvania
Lowe, C. C.	Genetics and Breeding	Cornell
Lucey, R. F.	Forage Management	Cornell
Lukezic, F. L.	Forage Pathology	Pennsylvania
MacCollom, G. B.	Entomology	Vermont
MacDonald, H. A.	Forage Management	Cornell
Marriott, L. F.	Soil Fertility	Pennsylvania
McKee, G. W.	Ecology, Physiology	Pennsylvania
Mears, D. R.	Agricultural Engineering	New Jersey
Merritt, T. L.	Animal Science	Pennsylvania
Millier, W. F.	Agricultural Engineering	Cornell
Mitchell, J. R.	Forage Management	New Hampshire
Mitchell, W. H.	Forage Management	Delaware
Morgan, O. D., Jr.	Plant Pathology	Maryland
Murphy, R. P.	Genetics and Breeding	Cornell
Nittler, L. W.	Seed Research	Geneva
O'Conner, J.	Animal Science	New Hampshire
Pardee, W. D.	Forage Management	Cornell
Parochetti, J. V.	Weed Control	Maryland
Partenheimer, E. J.	Agricultural Economics	Pennsylvania

Peters, R. A.	Weed Investigations	Connecticut
Pohlman, G. G.	Soil Fertility	West Virginia
Prince, R. P.	Agricultural Engineering	Connecticut
Race, S. R., Jr.	Forage Insects	New Jersey
Ramage, C. H.	Production Utilization	New Jersey
Reid, J. T.	Animal Nutrition	Cornell
Reid, R. L.	Animal Nutrition	West Virginia
Reitnour, C. M.	Horse Physiology	Delaware
Riker, J. T., III	Animal Husbandry	New Hampshire
Risius, M. L.	Genetics and Breeding	Pennsylvania
Routley, D. G.	Plant Chemistry	New Hampshire
Rowe, R. J.	Engineering Harvesting	Maine
Schillinger, J. A.	Plant Breeding	Maryland
Schneider, E. C.	Agricultural Engineering	Vermont
Schultz, O. E.	Plant Pathology	Cornell
Seaney, R. R.	Forage Management	Cornell
Simpson, G. W.	Forage Insects	Maine
Singley, M. E.	Engineering, Utilization	New Jersey
Smith, A. M.	Animal Nutrition	Vermont
Sprague, M. A.	Management, Preservation	New Jersey
Sproston, T.	Plant Pathology	Vermont
Starling, J. L.	Genetics and Breeding	Pennsylvania
Steinhauer, A. L.	Entomology	Maryland
Thomas, W. I.	Representing N.E. Directors	Pennsylvania
Toben, G. E.	Agricultural Economics	West Virginia
Ulrich, V.	Plant Breeding	West Virginia
Vander Noot, G. W.	Forage Utilization	New Jersey
Vandersall, J. H.	Dairy Science	Maryland
Van Soest, P. J.	Animal Nutrition	Cornell
Varney, K. E.	Forage Management	Vermont
Veatch, C.	Weed Control	West Virginia
Wakefield, R. C.	Forage Management	Rhode Island
Washko, J. B.	Forage Management	Pennsylvania
Washko, W. W.	Forage Management	Connecticut
Welch, J. G.	Nutritional Value	Vermont
Wiggans, S. C.	Plant Physiology	Vermont
Wilson, L. L.	Animal Science	Pennsylvania
Wood, G. M.	Forage and Turf Management	Vermont
Wright, M. J.	Forage Management	Cornell
Yendol, W. G.	Nonpesticide Insect Control	Pennsylvania
Zeiders, K. E.	Plant Pathology	Pasture Laboratory
Zwerman, P. J.	Soil Conservation	Cornell

INVITATIONAL PAPER

Land Resources and Their Utilization in
the Northeastern RegionR. B. Alderfer¹

Many people believe that sooner or later most, if not all, of the land in the northeast will be used to meet the manifold needs of an ever expanding, urban-industrial complex.

The implication is that our agricultural industry and particularly the animal products segment, will continue to decline and eventually be put out of business for the sheer lack of available space. To what extent will the shortage of suitable land in the northeast for agriculture determine whether this industry will continue to make up any significant part of the economy of the region? Knowing something about the amount of different kinds of land and what each is currently being used for, along with recent shifts in land use in the northeast might help in trying to answer this question. The best, if not the only available information about the land resources and their use in each of the 12 northeastern states, has been obtained by the Soil Conservation Service in its inventory of soil and water conservation needs in 1958 with projections for 1975 (summarized in USDA Misc. Publ. 971) and in a similar study done in 1967 (unpublished).

Examination of this information reveals some very interesting facts about the 127,618,800 acres of land in the 12 northeastern states:

1. At least 90% of it is not yet a part of the famous megalopolis, that supposedly near-solid metropolitan belt stretching from Boston to Washington, D.C.
2. About 40% of this "open" area of 50 million acres is suitable for the production of cultivated and forage crops (land capability classes I to IV), 20 million acres being in forest.
3. Much of the 60 million acres of land not suited for cultivation (capability classes V, VI, VII), is capable of being used for permanent hay or pasture; 80% of it is in forest.

¹Research Professor of Soils, N.J. Agricultural Experiment Station.

4. For the most part it is our present, and unfortunately often some of our best, crop and pasture land that is being converted or allowed to remain idle pending conversion to nonagricultural use. In New Jersey this has happened to 186,000 acres (15%) of such land, whereas land in forest (over 2 million acres or 40% of the state) has remained about the same between 1958 and 1967.
5. About 85% of the land in the northeast has something wrong with it in varying degrees (capability classes III to VIII) as regards its suitability for satisfactory crop production. Many of these limitations can be corrected or counteracted, whereas others just have to be tolerated. The most widespread, and often the most serious, limitations are those related to too much or too little water in the normal rooting zone of the soil at critical times during the year. Excess water or poor drainage is the dominant problem in at least 1/3 of this land. Equally widespread are the problems of too little, available water storage capacity due to low moisture retention and insufficient soil favorable to rooting caused by mechanical impedance (shallowness to bedrock, hardpan and tillage pans as well as hard, tight subsoils), acidity (too much soluble aluminum and/or manganese, or too little calcium), or low fertility. Stoniness, steepness of slope, susceptibility to erosion and to periodic overflow or surface flooding make up an additional group of problem conditions that usually render land unsuitable for cultivated but not necessarily for forage crop production. Low available nutrient storage capacity is another problem, but this can be taken care of fairly easily.

In view of these facts it seems rather evident that the decline of the agricultural industry in the northeast in the past, present and foreseeable future cannot be due primarily to any real lack of land that is now suitable or could be made so at no prohibitive cost. It is not realistic, however, to suppose that much of our present farmland near centers of expanding population and industrial development will not continue to go out of production. On the other hand, were the current economic and other problems confronting agriculture to change for the better or the necessary effort made to make farming an attractive business, there is enough suitable land, either cleared or in forest, far enough away from present high-pressure urban areas to support an animal-based, agricultural industry. The on-farm production of enough forage to meet as much as possible the nutritional needs of the animal, will depend upon how well we can do the following: fit the crops to those land conditions that are most difficult or too expensive to alter appreciably; change unfavorable land conditions by fitting the soil for a crop like alfalfa by artificial drainage; put to use all that we know or will learn about growing, handling and utilizing the crop.

It is going to take some modern pioneering to do this. Much of it will have to be done in the half of the region that most of the early settlers and those who followed them found least satisfactory for good farming with the means at hand to make it so. Whether most or all of our agriculture keeps going west and south or finds a place to thrive and grow in the northeast, will take the kind of imaginative thinking and doing that has characterized every other pioneering effort.

INVITATIONAL PAPER

Forage Quality and Fertility of Dairy Cattle

W. C. Wagner¹

Optimum fertility of the dairy cow is of vital importance to the dairy industry. Past estimates of losses from all forms of infertility in dairy cattle amounted to approximately 20 million dollars per year in New York State. Because infertility due to improper nutrition is ill-defined and frequently insidious in nature, the economic import of poor quality forage is not well known.

It is possible to delineate the problem of severe malnutrition when the animal is thin, stunted and obviously in poor condition. However, the role of mineral and/or vitamin deficiencies is difficult to establish and their presence or absence in a specific instance often difficult to prove.

As the economic picture of dairy farming has changed and the emphasis shifted to larger, more intensive operations, the dairy cow has become less of a roughage user. An increased portion of the diet must be in the form of concentrates in order to maintain an adequate energy intake and sustain a high level of milk production. With forage intake restricted, it is most important that it be of the highest quality. Since much of the concentrate now being fed is supplied by commercial organizations, it is usually supplemented with most of the minerals and vitamins that are of critical importance to the dairy cow.

Daily requirements of the dairy cow for minerals are as follows: cobalt, 0.3-0.5 mg; copper, 50 mg; zinc, 9 ppm; manganese, 20 ppm; magnesium, not known; calcium, 75 g; phosphorus, 63 g. The above values assume a 1200-lb cow giving 60 lb of milk per day. The problem in assigning numerical values to these mineral requirements is that the interrelationships between elements can cause major shifts in the requirement of a specific element at a specific time. Perhaps the prime example is copper. Excess amounts of molybdenum interfere with copper utilization so that a diet which contains adequate copper may still result in copper deficiency if molybdenum levels are high in the

¹Associate Professor, Veterinary Research, Iowa State University.

presence of sulfate in the diet. In fresh forage (green chop or pasture) substances in the porphyrin group can bind copper so that it is unavailable to the animal. The same forages, when dried, usually do not cause a problem.

Calcium and phosphorus are important for skeletal development of the fetus and during lactation. There are also reports of failure of estrus and lowered fertility resulting from phosphorus deficiency. Animals fed forage of reasonable quality generally obtain adequate calcium, especially if legumes are used as the roughage. Phosphorus requirements can usually be met quite easily by feeding grain supplements since forages are generally rather low in phosphorus.

Cobalt and copper are the two trace minerals most often mentioned as a source of reproductive problems. A deficiency of copper can result in poor growth, loss of condition, fading of hair color, anemia and diarrhea. Copper deficiency produces a demyelination in lambs born to copper-deficient ewes. The disease is known as "swayback." The defect is apparently associated with a deficiency of enzymes in the cytochrome series. It is not known whether the infertility results from similar enzyme deficiencies or as a result of the poor condition and debility that usually occurs in these conditions.

Cobalt is required by the ruminant for the synthesis of vitamin B₁₂ by the rumen bacteria. In those herds where cobalt deficiency was diagnosed, hemoglobin values of 7.00-9.00 g/100 ml were recorded. Similar levels of hemoglobinemia produced in experimental animals has also resulted in anestrus and impairment of ovarian function.

The cobalt and copper content of grasses is generally low irrespective of soil content. Legume plants, however, are able to store more of these elements and thus carry adequate levels for animal nutrition. Specific areas of the Northeast (northern New York, southeastern New Hampshire, southwestern Maine and southeastern Massachusetts) have been recognized as cobalt-deficient areas. Use of fertilizers containing cobalt sulfate can help alleviate the cobalt-deficiency problem.

If one feels that mineral deficiency may be a problem, supplementation using a mixture of dicalcium phosphate and trace mineralized salt (1:1) can be provided free choice to the cattle. However, in most instances cattle in a well-fed, well-managed herd will not show any response in fertility or milk production to extra mineral intake. Most commercial feed mixes already contain vitamin and mineral supplements.

Vitamin content of the forage portion of the diet is not of great importance to the dairy cow. The cow synthesizes the B-complex vitamins in the rumen. Sun-cured roughages generally supply adequate amounts of vitamins A and D. In addition, all dairy rations are heavily supplemented with these vitamins so that a deficiency is quite rare in the dairy animal.

It has long been recognized that certain strains of subterranean clover contain estrogenic material (genistein and biochanin A) that can cause hyperestrogenism and infertility in sheep and cattle. This problem has been mainly observed in Australia.

Bioassay of forage samples for estrogen content has been attempted at Cornell University with generally negative results. Recent studies in Israel have indicated that a substance present in alfalfa may be converted to an active estrogen by rumen bacteria and that standard bioassay studies in rats will not give a true picture of the potential estrogen content of a given forage sample.

An additional source of estrogens is fungi, particularly of the Fusarium group which is associated with moldy corn or corn silage. The active compound is a derivative of resorcinylic acid. Although the problem is more frequently seen in swine due to their high corn diet, contaminated high moisture corn or corn silage fed to cattle could result in hyperestrogenism. Animals receiving this material may show swollen vulva, mucus discharge, occasional abortions and impaired lactation.

From this brief survey, it is evident that mineral intake can be influenced by the forage in the diet. Since the forage usually reflects the soils on which they are grown, appropriate fertilization practices can influence some of the mineral components. One should also remember that grasses are generally low in certain of the trace elements irrespective of the soil content. Because of the complex relationships of some of the minerals, a simple determination of the mineral content of a given forage may not indicate the availability of such minerals to the animal.

Careful examination is needed to determine accurately the possible role of estrogens from forages in causing hyperestrogenic signs in cattle. Previous negative findings may need to be reevaluated.

INVITATIONAL PAPER

The Utilization of Forages by the Ruminant

Heinrich Fenner¹

All our efforts in rational forage production, management, and preservation are directed towards providing the ruminant with its most original feed. The bovine as the dominant inhabitant of grasslands (the prairie) developed its present digestion system with the predominant consumption of roughage or forage. Forages in their physical form and chemical composition have developed the nature and the requirements of the digestion processes in the rumen. The coarseness of roughage has developed the saliva flow which regulates, with its major inorganic component sodium bicarbonate, the microbial degradation processes by buffering the bacterial wastes, namely the volatile fatty acids (VFA), and accelerates their absorption through the rumen walls. The organic components of the forages serve as growth media for the microbial population in the rumen. Changes in their composition can, to some extent, alter the ratio of individual VFA of the total acid concentration. The inorganic components of the forage, especially the major base-forming elements such as Ca and Mg, become available in the rumen in direct relationship to the concentration of the VFA present. The ruminant is fairly independent of the need for high-quality proteins. The microbes in the rumen consume most of the feed protein first and then serve as the protein source for their host. Since bacteria can thrive well on simple N-compounds, the use of urea as part of the protein in rations is widely practiced. In times of need nature has also provided the ruminant with a source of simple nitrogen compounds. Urea is recirculated via saliva and re-entrance through the rumen walls to the digesta for resynthesis to microbial protein. Here the VFA serve as the energy source for the amino acid synthesis. The concentration of VFA found in the rumen should be regarded only as the difference between rate of production and rate of absorption. Since production and absorption are controlled independently, a knowledge of the concentration of VFA alone does not say much. A high concentration can result from not only high production but also from a slow absorption.

An increased intake of the same feed causes an increased concentration of metabolites in the rumen. However, an increased digestibility at

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the same level of intake and similar physical form does not necessarily change the concentration of metabolites in the rumen. When a roughage is offered at equal rate of intake but in different physical forms such as pelleted, wafered, or as long hays, the reduced physical size of the processed forage raises the concentration of total VFA and the proportions of propionic and butyric acids and lowers the proportions of acetate in the rumen, the digestibility of dry matter and of the structural carbohydrates. These effects are caused by the increased rate of passage through the digestive tract and a reduced secretion of saliva due to the lack of stimulation for rumination. If the physical nature of the ration is maintained, the ruminant succeeds within its limits to provide a fairly constant environment for the microbial population. This is accomplished by keeping the pH within the range of changes caused by the common system of periodical feedings. The increased production of VFA after feed intake exceeds the rate of absorption and increases the total VFA and H-ion concentration during the first 3-5 hr after feeding. At the concentration peak, production and removal rate are equal. Hereafter the absorption exceeds the production, which causes a declining total acid concentration and rising pH. The differences in accessibility of the various nutrients in the forage to microbial attack and the differences in pH optima of various enzymes cause different rates of production of the two major acids. So, the proportion of propionate as the product of the easily available plant carbohydrate digestion, will increase after feeding and the proportion of acetate as the major product of cellulose digestion will decrease. During the later hours after feeding, the changes in the proportions of acetic and propionic acids reverse their trends and revert to the pre-feeding concentrations. Changes in the proportion of the other acids are also observed; however, these are not as persistent as those observed with the two major acids.

There are commonly seven different VFA present in the rumen fluid of which acetic, propionic and butyric acids represent more than 90% of the total. Isobutyric, isovaleric and n-valeric are found in proportions of up to 2-4% each and n-caproic acid in a few tenths of a percent. Since 60-80% of the ruminant's energy requirement is met by these acids, a knowledge of their mode of conversion from the ration is important. The average proportions of these individual acids of the total acid concentration are as follows:

$$\begin{array}{llll} C_2 = 62-65\% & \text{iso-}C_4 = 0.8-1.5\% & \text{iso-}C_5 = 2.0-4.0\% & n-C_6 = 0.2-4.0\% \\ C_3 = 18-20\% & n-C_4 = 9-12\% & n-C_5 = 1.5-2.5\% & \end{array}$$

Changes induced by different rations, mainly containing forage in its natural form, on the proportion of the three major acids are relatively small in comparison to those of the four minor acids. Since their energy contribution compared with the total content is small, the four minor acids have so far received little attention.

In conclusion it should be stated that this paper contains only a small part of the general knowledge on rumen digestion. Many of the statements made have been based on the results of our experiments.

RESEARCH IN THE NORTHEASTERN REGION

Section I

Plant Introduction, Genetics, Breeding,
Strain Evaluation, etc.

Title: PROJECT NE-9 - THE INTRODUCTION, TESTING, MULTIPLICATION, AND PRESERVATION OF POTENTIALLY VALUABLE PLANTS FOR CROP IMPROVEMENT AND INDUSTRIAL USE

Leaders: D. D. Dolan, Coordinator and E. P. Brasher, Chairman, Regional Technical Committee; S. W. Braverman and W. R. Sherring

Cooperators: Fourteen State Agricultural Experiment Stations of the 12 Northeastern States, the New Crops Research Branch, ARS; the Cooperative State Research Service, the Soil Conservation Service, and the Forest Service, USDA

Plantings at the Regional Station, Geneva, in 1969 included 950 forage legumes and grasses, of which 434 were carried over from 1968. Descriptive and evaluative notes were recorded on all introductions, and the information was reported in the biennial catalog. Some promising introductions were as follows:

Alfalfa introductions PI 172429 and PI 260993, showed relatively little damage by the alfalfa weevil as well as good spring growth and good recovery after clipping in Beltsville tests.

Low levels of resistance to Leptosphaerulina briosiana were found in seven of twenty-four introductions screened at the Pasture Laboratory.

PI 231731, Medicago falcata, was hardy, leafy and fairly vigorous in tests at Ottawa, Canada. PI 325402, M. romanica, was hardy and gave good forage production at this location.

Five introduced red clovers (PI 204508 and 233827-29) showed varied resistance to a Maryland strain of the pea aphid, with two introductions rated as resistant and one as moderately resistant.

Three accessions of Lotus cornic. var. ciliatus (PI 214112-13 and 251146) demonstrated complete winterhardiness after two Canadian winters.

Of many introductions of brome grass tested at Saskatoon, three (PI 204432-33 and 206418) had substantial resistance to Selenophoma bromigena leafspot.

A perennial ryegrass introduction (PI 290368) that showed good winter-hardiness and spring recovery has been used in breeding programs in Connecticut.

Three introductions of Lolium (PI 251142, 265335 and 272121) were promising in tests for winterhardiness and spring recovery in Alberta, Canada.

An introduction (PI 257270) of perennial ryegrass from Sweden, has shown potential as a hay and pasture variety in Quebec, Canada.

A supplement reported observations made during the summer and fall on earlier plantings of many forage grass and legume species. Vigor, leafiness, time of bloom, hardiness, spring recovery, disease and insect resistance, and other characteristics were evaluated and promising introductions identified. A large number of alfalfas from both 1968 and 1969 plantings showed resistance to common leafspot caused by Pseudopeziza medicaginis, and many of the 1968 introductions exhibited good winterhardiness and spring recovery. Four of the 1969 alfalfa introductions were rated highly for leafiness, vigor and common leaf-spot resistance.

Several red clover introductions showed promise of producing into the third harvest year, and PI 246751 (a white clover from Spain) had good winterhardiness, spring recovery, persistence, vigor and leafiness through two seasons. Another white clover appeared to be a strong spreader, vigorous, leafy, a good seeder and free from leafhopper damage. Desirable winterhardiness, spring recovery, vigor, leafiness and fall recovery were found in eleven introductions of birdsfoot trefoil. The 1969 trefoil introductions include many that have promising characteristics. Many 1968 and 1969 introduced forage grasses are also promising.

The supplement on disease resistance of plant introductions reported the screening of a collection of alsike clover for resistance or tolerance to yellow bean mosaic virus. The eleven clones showing resistance will be field planted and observed through 1970-1971. The best red clovers, selected from 1962-1968 for field tolerance to powdery mildew, yellow bean mosaic virus and winterhardiness have been planted for 2-3 years of field observations. Evaluation of alsike clover for resistance to Stemphylium sarciniforme is planned for next year. Myrothecium verrucaria was isolated from Lotus corniculatus and screening with this organism is also planned.

Title: PROJECT NE-28 - BREEDING OF IMPROVED VARIETIES OF FORAGE SPECIES ADAPTED TO THE NORTHEAST

Leader: M. L. Risius, Chairman, Regional Technical Committee

Contributors: The Connecticut, Maryland, New Hampshire, New York, Pennsylvania and West Virginia Agricultural Experiment Stations, the U.S. Regional Pasture Research Laboratory, and Forage and Range Research Branch, ARS, the Cooperative State Research Service, USDA, and the American Seed Trade Association

Substantial effort was given to evaluation of synthesis procedures. Other phases of the present project continued in 1969 included genetic studies, cooperative seed production, and synthesis and evaluation of new varieties. Work is in progress on five species at six Northeastern State Experiment Stations and the U.S. Regional Pasture Research Laboratory.

I. Evaluation of synthesis procedures for perennial forage species.

Alfalfa - The inbreeding program with USDA MS-A and MS-B gene pools was continued. The S₀, S₂, and S₄ generations in each pool have been sampled and diallel combinations are being made to measure the effects of parental inbreeding on single-cross and double-cross performance (Pasture Laboratory).

Studies on double-cross alfalfa synthetics were completed. Seed production techniques were shown to affect forage yield through influences on the percentage of crossed and selfed seed. Conventional synthetics were equal to or better than double crosses from the same parents. A manuscript is being prepared for publication.

Timothy - Variety synthesis investigations indicated that the best single-clone derived lines were equal to the best cross combinations in forage yield. Derived-line crosses were equal to comparable two-clone hybrids in forage yield but inferior in seed production. The greatest advantage of true hybrids may be in seed production potential rather than in direct use as varieties.

Orchardgrass - Preliminary data indicated that there was no yield advantage from double crosses or single crosses between lines over stabilized synthetics in Pennmead or Pennlate stocks.

Bromegrass - In diallel single-cross studies, there was a 10% yield decrease from the Syn 1 to the Syn 2 generation. General combining ability was more important than specific combining ability. A manuscript summarizing results of diallel crosses was accepted for publication.

II. Genetic studies.

Alfalfa - Sufficient seed set on single-clone derived synthetics was obtained to establish a test that will be used to study genetic models (Pasture Laboratory).

Bromegrass - The temperature sensitive albino mutant had 55 chromosomes and pairing occurred largely as bivalents. Segregation data obtained from F_2 , F_3 , and backcross generations fit a tetraploid model much better than either disomic, hexasomic or octosomic models (N.H.).

III. Seed production.

Seed was produced in seven cage isolations of bromegrass mutant combinations. Field isolation plots for seed production of three bromegrass synthetics were established. Seed production was obtained with 26-cage isolations of timothy and 6-cage isolations of bromegrass. Plant growth chambers have been shown to be feasible for seed production on alfalfa.

IV. Evaluation of new synthetic varieties.

Comparative yield trials designed to evaluate newly synthesized varieties and those in current use are being conducted in six states. Some of these trials provide information on variety synthesis procedures. Among the varieties of orchardgrass, timothy, trefoil, and alfalfa synthesized during the course of this project, there are some that show sufficient superiority over currently available varieties to warrant increase for more extensive testing and possible release and distribution.

USEFULNESS OF FINDINGS:

Perennial forage varieties developed through cooperation with the NE-28 project constituted 70% of the alfalfa, 36% of the bromegrass, 21% of the orchardgrass, and 2% of the timothy seed used in the Northeastern States in 1969. Use of improved varieties in the region is increasing and considerable use outside the region is being observed. Surveys from the 12 Northeastern States show that 6,200,000 lb out of the total 8,200,000 lb of seed sold of the species included in this project were of varieties identified through this project or its predecessors.

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS ON ALFALFA

Leaders: R. F. Murphy and C. C. Lowe, Cornell

1. A preliminary investigation on leaf-stem ratio in alfalfa is in progress with emphasis on multifoliolate selections. Between-plant variation is large in check varieties. Significant intraline and interline variations were evident in the multifoliolate breeding materials. Whole plant separation has been used to determine range but this is too time consuming and expensive for screening or genetic study. More efficient estimation methods are being studied.
2. A source of cytoplasmic male sterility found in the variety Saranac is being studied in hybrids between male-sterile Saranac and plants from the variety Iroquois and male-sterile Saranac X yellow-flowered Iroquois plants. Progenies examined vary widely in sterility, none are completely sterile or restored.
3. Seventeen synthetics are being evaluated from recurrent selection programs for populations started from introductions, domestic breeding lines, weevil tolerant selections and sources carrying other agronomic features. On the basis of early test results, synthetics with parents out of New York varieties, other U.S. lines and variegated plants from the variety Saranac have shown greatest promise. Synthetic N, a yellow-flowered synthetic from plants out of the variety Iroquois shows distinctly different growth characteristics from the parent variety. Testing is continuing on all synthetics and their parent clones.
4. A program for developing inbred lines from the varieties Saranac and Iroquois is also in progress. Two-year inbreds from Saranac totalling 2700, were selfed with 60% setting seed and 5% highly self-fertile. Deleterious phenotypes from recessive gene segregation have been infrequent.

Title: INBREEDING IN ALFALFA

Leader: R. R. Hill, Jr., Pasture Laboratory

A program of selfing was initiated in a random sample of clones from each of two alfalfa populations designated Pool A and Pool B (see 1968 Annual Report, p. 17). Seed production on S₅ lines was so poor that the sample of S₆ lines for evaluation of the effects of parental inbreeding on performance of hybrids and synthetics was inadequate.

Therefore, samples were taken from S_0 , S_2 , and S_4 generations. Single cross seed production has been started on two 5-clone diallel crosses in each generation and each pool.

Seed production on single-clone-derived synthetics was also poor, but enough seed were obtained in enough families to provide a test of a genetic model which has been developed. Modifications had to be made in original plans (see 1968 Annual Report, p. 18), but test of parameters in the model will still be possible.

Title: VARIABILITY AMONG SYNTHETIC VARIETIES OF ALFALFA

Leader: R. R. Hill, Jr., Pasture Laboratory

The Syn 2 generations of 60 4-clone alfalfa synthetics are being studied to obtain information on the nature of variability among alfalfa synthetics. Thirty-six of the synthetics were made from randomly selected clones from a program to develop wilt resistance in DuPuits, and 24 of the synthetics were made from clones which trace to selections made by B. A. Brown of Connecticut. Within each population (DuPuits and Connecticut clones) the synthetics were made according to a mating design which would permit estimation of variability due to the average effects of clones and interactions between them (see Hill, R. R., Jr. 1966, Crop Sci. 6: 471-473).

Spring growth, recovery after the first harvest, fall growth, and yield for each of three harvests were measured on row plots (12 plants in an 8-ft row; rows on 15-inch centers). The greatest source of variation was between populations (DuPuits vs Connecticut), and there was very little variation among synthetics within populations. This was true for all characters studied. Reaction of the synthetics to various alfalfa pathogens is being obtained in a greenhouse study, but these data have not been summarized.

It was possible to approximate the variance among stable synthetic varieties in terms of genetic components of variance in a theoretical study. The mean of all possible synthetics from a population would be less than the mean of the parent population when nonadditive, genetic effects are present and the number of parent clones per synthetic is small. As the number of parent clones per synthetic increases, the mean of all synthetics approaches that of the original population. The variance among synthetics decreases rapidly as the number of parent clones per synthetic increases, and the decrease is very rapid for nonadditive genetic variance. These conclusions hold equally well for diploids and autotetraploids.

Title: BREEDING OF ALFALFA

Leaders: J. A. Schillinger and J. C. Hanson, Maryland

Two primary lines of work are being pursued. These include breeding of insect resistant alfalfa varieties. Insects being considered are the alfalfa weevil, potato leafhopper and red spider mite. Another line of research includes breeding for high protein content of alfalfa through the use of Princep (simazine) at sub or minimal herbicidal levels.

Title: VARIATION IN SUSCEPTIBILITY AND RESISTANCE TO SCLEROTINIA
ROOT AND CROWN ROT OF ALFALFA

Leaders: O. D. Morgan and J. A. Schillinger, Maryland

Old field selections, 10-12 years old, of Williamsburg variety do not show any more resistance than one-year selections in greenhouse tests. Individual plant variation ranges from no survivors to 60%. The F₃ selfed progenies of a polycross population of Medicago sativa var. gaetula, M. sativa cv Narragansett, and M. tianschanica indicates that gaetula has fewer selections showing resistance than Narragansett and M. tianschanica. As with Williamsburg the polycross progenies show a wide range of resistance among individual selections. The variety gaetula shows none to 70% resistance, Narragansett varies from none to 63% and M. tianschanica varies from none to 47%. This wide range of variation has occurred also in the F₁ and F₂ progeny; however, there is a gradual increase of the number of selections showing resistance to Sclerotinia. The new variety Team which has resistance to the alfalfa weevil, anthracnose, and the common leafspot was highly susceptible to Sclerotinia root and crown rot over the past 2 years.

Title: BREEDING OF RED CLOVER

Leaders: J. A. Schillinger and O. D. Morgan, Maryland

Seven red clover synthetics, parental clones of which were developed by maternal line selection method, were compared with five red clover varieties and breeding lines. Total forage yields for 1969 ranged from 3.22 to 2.65 tons per acre. Synthetic Md 67-A2 produced the highest yield and had significantly more persistent plants 18 months after seeding than Chesapeake or Pennscott varieties.

Vigor, tolerance to leafhopper yellowing, downy mildew, and persistence data were recorded for 200 plant introductions during 1969 in a source nursery at Clarksville. Final selections for vigor and persistence will be made during 1970.

Title: THE BREEDING, GENETICS AND CYTOLOGY OF FORAGE LEGUMES

Leaders: R. W. Cleveland, J. L. Starling, and M. L. Risius,
Pennsylvania

The breeding for resistance in red clover to the northern anthracnose disease was continued. A generation of plants was inoculated and selections made for apparent resistance. The same plants were inoculated and selected for southern anthracnose and for powdery mildew resistance. Disease levels attained for the three diseases were very good, giving reasonable assurance that selections could be effectively made. Selected plants were intercrossed in a field isolation block and good seed yields were obtained. The progeny were planted for a repetition of the disease testing and selection in the new generation.

Plants of alfalfa resistant to southern anthracnose were selected in five varieties of this species. Inoculation produced high disease levels needed for efficient selection. A succeeding generation was produced from the plants. Present indications are favorable for genetic improvements for this disease.

Field experiments for forage yield testing of legume varieties were established and harvested. Several new alfalfa varieties were found to be promising in yield performance, however many varieties were found to be susceptible to southern anthracnose. The latter factor may limit the yield of alfalfas used in southern Pennsylvania.

Studies of meiosis in crownvetch has shown that plants of two varieties behave like autotetraploids.

A nursery for the continuation of breeding of creeping-rooted alfalfa lines was established.

Title: BREEDING CROWNVETCH FOR FORAGE AND SLOPE STABILIZATION

Leaders: M. L. Risius, R. W. Cleveland, and J. L. Starling,
Pennsylvania

Additional studies on self- and cross-fertility support previous findings that crownvetch exhibits a high degree of self-incompatibility. However, an occasional plant is found that sets seed readily after self-pollination. Preliminary studies have been made on the behavior of pollen after pollination. Microscopic examination of stigmas from 18 different plants at 6, 12 and 24 hr after pollination indicated that low seed set from self-pollination is due to the lack of pollen germination and severe inhibition of pollen tube growth. Results with cross-pollinations have been strikingly different. The pollen appeared to have germinated well and pollen tubes were found in the ovary after 24 hr.

Studies concerning the nature of inheritance in Coronilla varia are being continued. Crosses involving flower color and chlorophyll mutant characters were advanced. Problems with incompatibility have slowed progress in producing the necessary crosses and the number of plants required to define the inheritance pattern of the characters being studied. Recent evidence suggests that more than one gene locus may be involved in the control of the white flower color trait.

Evaluation of the potential of crownvetch as a forage crop in small plot seedings is being continued. Results have not been consistent. Preliminary results suggested that the Chemung variety would outyield Penngift. Subsequent trials have indicated that the three crownvetch varieties (Chemung, Penngift, and Emerald) are nearly the same in their forage yield potential.

Title: BREEDING OF IMPROVED VARIETIES OF FORAGE SPECIES ADAPTED
TO THE NORTHEAST

Leaders: R. W. Cleveland, J. L. Starling, and M. L. Risius,
Pennsylvania

Seed progenies for use in variety synthesis studies of orchardgrass were produced by means of cage isolation blocks. Fair-to-good seed production was obtained from the six double-cross combinations attempted.

An orchardgrass synthesis experiment was evaluated in the first harvest year. A tentative conclusion which comes from the data is that double-cross combinations of two groups of clones do not differ greatly in

yield from stabilized synthetics derived from the same clones. When the information is complete from this and similar experiments, it will enable orchardgrass selections to be used in the most productive breeding combinations.

A field experiment for testing birdsfoot trefoil experimental varieties was established but no information was obtained on forage yield. The planting was maintained for future evaluations of these varieties bred in New York. Timothy field experiments to evaluate synthesis procedures were planted, but failed to develop adequate stands.

Title: THE BREEDING AND CYTOGENETICS OF PERENNIAL FORAGE GRASSES

Leaders: J. L. Starling, R. W. Cleveland, and M. L. Risius,
Pennsylvania

Work was completed and data summarized in a study of the effects of certain environmental factors on pollen germination, pollen tube growth and seed set in brome grass and orchardgrass. Of several alternative methods of constructing isolation cages, the single layer, muslin-covered cage was as satisfactory as any in terms of viable seed production. The light reduction in this conventional cage was not a seriously limiting factor to seed set in orchardgrass and brome grass. Relatively poorer seed set in brome grass under cages was attributed to poor pollen distribution.

First-year data were collected from a forage trial in which seed from several areas of production and several generations of Pennlate orchardgrass are being compared. Data collected to date indicate all seed lots are similar in performance and do not differ from the yield of plots seeded with Syn 1 seed.

Variety trials of orchardgrass and brome grass at the Southwest Field Research Laboratory at Ligonier and at the Agronomy Research Farm were harvested and new trials were established at two locations.

Title: BREEDING AND GENETICS OF BROMUS INERMIS

Leaders: G. M. Dunn and M. Nasiruddin, New Hampshire

The Syn 2 generation averaged about 10% lower in forage yield than did the Syn 1 generation in diallel crosses among six noninbred clones of Bromus inermis. General was much more important than specific combining ability in this material. Additional tests have been established

to compare the first two synthetic generations where the number of parental clones per synthetic varied from two to six.

Segregation data obtained with the temperature-sensitive albino mutation in F_2 , F_3 and backcross generations fitted a tetrasomic model but did not fit disomic, hexasomic or octosomic models. Ratios obtained in backcrosses usually fell between chromosome and chromatid segregation.

Title: FORAGE PRODUCTION BY SWITCHGRASS AND NONHEADING ORCHARDGRASS

Leader: C. C. Berg, Pasture Laboratory

Sometimes questions are raised about the possibility of growing warm-season grasses in this region with the goal of increasing the amount of forage that can be produced and harvested in the warm midsummer growing period. Therefore, seven varieties of switchgrass were included in a nursery seeded in June 1968 to provide information on this subject. Syn 2 generation of the three nonheading orchardgrass synthetics A, B, and C developed at the U.S. Regional Pasture Research Laboratory (seed produced at Prosser, Wash.) were also included in the nursery for comparison and to obtain yield data on these selections.

Stand establishment and survival in the tall fescue and orchardgrass plots were good. However, poor establishment and winter injury resulted in poorer survival of switchgrass varieties (see table on page 23).

The nursery was harvested on May 15, 1969 and at monthly intervals through September 15, 1969 for a total of five harvests. The total dry matter yields of all orchardgrass and tall fescue entries shown below were not statistically different at the 1% level but were superior to the switchgrass varieties. The switchgrass varieties that survived were not much more productive than weeds. Although the midsummer production by the switchgrass varieties was about 20% higher than the cool-season entries, the switchgrass varieties did not make significant growth until late May or early June, and stopped growing in late August. The tall fescue and orchardgrass entries had produced about 3000 kg/ha dry matter in the spring before the switchgrass varieties began to grow.

On the basis of one season's production in this single test at one location, with frequent harvests, switchgrass does not appear to be a reasonable alternative to orchardgrass or tall fescue.

Total dry matter yields from five harvests in 1969.

Variety	Kg/ha	Variety	Kg/ha
Kenwell TF	10177 a*	Caddo	6375 bc*
Ky 31 TF	10643 a	Summer	5613 cd
Pennmead OG	10449 a	Pathfinder	7031 b
Pennlate OG	10327 a	Blackwell**	5197 d
Syn A OG	10577 a	Nebraska 28**	5391 cd
B	9900 a	Pangburn**	4855 d
C	9804 a	Kanlow**	4825 d

* Duncan's Multiple Range Test: means followed by the same letter are not significantly different at the 5% level.

** Switchgrass replaced by weeds.

Title: PROJECT NEM-22 - FACILITATING THE MARKETING OF SEED OF FORAGE AND TURF CROPS THROUGH DEVELOPMENT OF TECHNIQUES FOR EVALUATING VARIETAL PURITY AND IDENTITY

Leader: L. W. Nittler, Chairman, Regional Technical Committee

Cooperators: The New York (Geneva and Ithaca) and Pennsylvania Agricultural Experiment Stations, the Forage and Range Research Branch, Crops Research Division, the Market Quality Research Division, ARS, the Seed Branch C&MS, USDA

Different approaches to the problem of developing improved techniques for identifying varieties were explored at four locations. At Geneva, New York research was concentrated on inducing morphological differences among varieties in the seedling stage. Seedlings of eight red fescue varieties were sprayed with ethrel solutions. Normally plants

of this species do not elongate stems unless they are subjected to a cold period. However, as a result of using this chemical, stems of three varieties elongated and plants were easy to distinguish from the other five. Varieties also differed in length of leaf blades, anthocyanin development, and rate of stem elongation.

Stems of plants of eight timothy varieties elongated when grown with continuous light. Varieties differed significantly in length of the first, second, and third internodes above the crown.

Kentucky bluegrass varieties were grown with a nutrient solution lacking calcium. Eleven became very chlorotic within 4 weeks, six remained green, and six were mixtures of chlorotic and normal plants.

Twenty-four oat varieties were grown two weeks with a nutrient solution lacking phosphorus and then with a complete solution for 2 weeks. Severe chlorosis developed in the blade of the first leaf of some varieties, but others developed very little chlorosis. In some varieties the internode between the first and second leaf nodes was greatly elongated, but in other varieties this internode was short.

At Ithaca, New York a chemical spot test was used to measure peroxidase activity of seed of 67 spring barley varieties. Individual seeds were tested by putting them in 1 ml of 0.1% hydrogen peroxide saturated with benzidine dihydrochloride. A blue color developed in 5 minutes in varieties with "high" peroxidase activity. No color developed in varieties with "low" activity. The source of activity appeared to be in the endosperm, as a seed had to be crushed for color to develop. Ten varieties were classed as low and the other 57 showed varying degrees of high activity.

At Pennsylvania State University studies continued on application of instrumental techniques and biochemical differences of crops for varietal characterization. In crownvetch tests based on content of leucoanthocyanin in seed or leaf and comparative cotyledon size of plants grown under standard conditions served to characterize adequately most seed lots of the three released varieties, Chemung, Emerald, and Penngift.

In continuing studies on varietal differences in flower color, chromatograms were run on several hundred flowers of three varieties of crownvetch and two of birdsfoot trefoil. Biochemical differences between varieties within a species were minor in magnitude and quantitative in nature.

Plants of 60 alfalfa varieties were grown in chambers under 2 different environments. Comparative data were secured on height, internode number, leaf color, flower color, and leaf serration. Studies on rooting habit of several varieties of alfalfa and crownvetch were concluded. While varietal differences were found this technique does not appear useful for varietal characterization.

Studies of 143 varieties of hybrid field corn indicated that leaf number per plant was relatively stable for a variety and little affected by environment. Leaf number was evaluated on 3- to 5-week-old plants grown in the greenhouse.

Studies were started to isolate and identify biochemical constituents extracted from several varieties each of Kentucky bluegrass and ryegrass.

At the Market Quality Research Division, ARS, USDA, Beltsville, Md. two enzyme systems useful for distinguishing soybean varieties were found. One of these is called INT oxidase because of the unidentified enzyme's ability to keep iodinitro tetrazolium violet in an oxidized state. The other is an esterase as detected by starch-gel electrophoresis.

USEFULNESS OF FINDINGS:

Varietal purity tests developed under this project are being used by seed companies, certification agencies, and law enforcement agencies to improve genetic purity of seed being sold. One company is using a discovery from this project to detect fields which produce seed contaminated as to variety and thus eliminate them. Information from this project will also help breeders to produce varieties that can be identified in a short time. These developments promote accurate labeling of seed and thus improve seed marketing.

Section II

Plant Pathology, Entomology, Selection for Disease
and Insect Resistance, Control, etc.

Title: PROJECT NE-45 - THE ROLE OF FUSARIUM SSP. AS CROWN AND ROOT
PATHOGENS OF FORAGE LEGUMES

Leader: F. L. Howard, Chairman, Regional Technical Committee

Contributors: The Agricultural Experiment Stations of Delaware, New
Jersey, Pennsylvania, Rhode Island, and West Virginia,
the U.S. Regional Pasture Research Laboratory, the
Forage and Range Research Branch, ARS, and the Coopera-
tive State Research Service, USDA

The effects of potassium and calcium salts on disease development in alfalfa roots exposed to Fusarium oxysporum f. batatas were evaluated in Delaware. Solutions of K_2SO_4 , $CaSO_4$ and $CaCl_2$ at concentrations of 10,000, 1,000, and 100 ppm were injected into the root zone below the fungus inoculation sites in 7-year-old, field-grown plants of Vernal, Narragansett and Williamsburg alfalfa. After 3 months the roots were examined for damage. Vernal was least injured, and the other two were comparable. $CaCl_2$ at 10,000 ppm favored the highest disease index in Narragansett and Vernal. $CaSO_4$ at 10,000 and 1,000 ppm produced equal stress levels on Williamsburg, but not on Vernal at any concentration. K_2SO_4 did not visibly affect Williamsburg and Narragansett. A greenhouse study of high levels of K on tissue damage in alfalfa infected by F. oxysporum f. batatas was completed. The varieties were ranked in decreasing order of tissue damage; i.e., Narragansett, Williamsburg and Vernal. The extent of diseased tissue was inversely related to the amount of K in the leaves.

Pennsylvania investigated the relative effect of K, Ca and N source on Fusarium tricinatum and the alfalfa host regarding root rot development. Roots of 3-month-old DuPuits plants growing in sand were irrigated with Hoagland's solution containing 0, 1/2, 1 and 2 times the K content specified, and half the plants were inoculated with F. tricinatum chlamydo-spores. Three months later infected roots had a reduced dry weight except those exposed to 2x K. One-month-old seedlings growing in a standard medium were exposed to F. tricinatum and F. roseum growing on a medium containing a dosage series of K. Seemingly K influenced the fungus, since at lower K levels more plants were killed and the rate of attrition was also higher.

In Rhode Island alfalfa seedlings grown gnotobiotically at pH 4, 6, 7, 8 and 9 produced exudate that stimulated Rhizobium meliloti grown 4x to 5x and 3x at pH 5. Components of exudate from seedlings grown at pH 4, 5, and 6 were separated by ion-exchange resin using acetic acid, water and triethylamine (TEA) sequential elution. The acetic acid-water eluent inhibited rhizobial growth, whereas the TEA eluent caused stimulation similar to the original exudate. Technicon auto-analysis of ninhydrin-positive substances in the TEA eluent showed 4 peaks representing free α -amino N compounds. Standards consisted of 20 amino acids and 2 sugar amines. Alteration of pH under which seedlings were grown affected the quantity of the 4 major exudate substances, which have a basic charge and probably are amino-acids, peptides, or glycosides. Of 8 amino acids corresponding to the elution points of the 4 observed peaks, only the sulfhydryl-containing cysteine markedly stimulated the growth of R. meliloti.

An accelerated growth chamber method for determining the effect of foliage removal from red clover and alfalfa on Fusarium root rot incidence was developed at West Virginia. No "wild" red clover collection resistant to red clover vein mosaic virus was found among those assayed.

Studies at the U.S. Regional Pasture Research Laboratory indicated that age of nonseedling plants when inoculated, soil temperature, and inoculation frequency did not increase development of root rot in red clover. Addition of washed hyphae of F. roseum to the soil stimulated clover growth, as measured by fresh weight of clippings. Saponins from alfalfa greatly increased growth of F. roseum, but inhibited Pythium spp. and Trichoderma viride.

Emphasis in the birdsfoot trefoil improvement program at Beltsville is being shifted from root and crown rots to foliar diseases. Resistance is known for some of these diseases but has not been exploited. A dry inoculum has been developed to screen alfalfa populations for resistance to Colletotrichum trifolii. The inoculum (1) is virulent after 4 months frozen storage, (2) can be used and increased by nontechnical personnel, and (3) allows breeders to work independently of plant pathologists.

USEFULNESS OF FINDINGS:

The effects of the elements Ca and K on the resistance of alfalfa roots and on the virulence of the Fusarium have been indicated. This knowledge could be used to manage fertilizer applications to minimize root rot injury. Alfalfa root exudate contributes to antagonism between Fusarium and other soil microbes such as Rhizobium. Since a cysteine-like compound is exuded in quantities that stimulate growth of Rhizobium, the conditions for maximum biosynthesis can be established. Criteria for optimum foliage removal from red clover and alfalfa to minimize root rot development can be formulated.

Title: EFFECT OF SAPONIN AND NONSAPONIN FRACTIONS FROM ALFALFA
ON THE GROWTH OF PATHOGENIC FUNGI

Leader: K. T. Leath, Pasture Laboratory

This research is part of a cooperative study to characterize alfalfa saponins. Plant materials of DuPuits and Lahontan alfalfa were grown and prepared by M. W. Pedersen, Logan, Utah. Saponin extractions were made by the Research Triangle Institute, Research Triangle Park, N.C., and supported by U.S. Department of Agriculture Contract No. 12-14-100-8930 (34). Various alfalfa extracts were tested for their effects on the vegetative growth of ten alfalfa pathogens. Assays consisted of growing the fungi on agar containing from 0.001-10.0 mg/ml of the fractions. Like fractions from Lahontan and DuPuits alfalfas were tested. Growth of Ascochyta imperfecta and Leptosphaerulina briosiana was generally unaffected; Fusarium oxysporum was inhibited on most fractions; but F. roseum was generally stimulated with growth on the hexane-heptane fraction nearly three times greater than that of the control. Growth of other fungi tested was generally inhibited. Pythium debaryanum, P. irregulare and P. ultimum were completely inhibited or nearly so by both saponin and nonsaponin fractions. Sclerotinia trifoliorum was also inhibited but to a lesser degree. Growth of a Rhizoctonia sp. on saponin agar was less than half that on control agar. Like fractions from DuPuits and Lahontan varied slightly in effectiveness; one fraction was fungistatic or fungicidal depending upon the test fungi used. In another test ten isolates of Fusarium, representing three species, showed varied responses to both saponin and nonsaponin fractions, but these responses were not species related.

Title: THE ROLE OF FUSARIUM SPP. AS CROWN AND ROOT PATHOGENS OF
FORAGE LEGUMES

Leader: F. L. Lukezic, Pennsylvania

Greenhouse tests were completed to determine if reported effects of mineral nutrition on Fusarium root rot on the host or on the parasite. The use of a nutrient solution with different levels of potassium as an irrigation liquid showed that there was a reduction in root dry weight when Fusarium tricinctum was present at all concentrations except at the highest. The same solution used as a nutrient source for mycelial growth of the fungus was not effective except at the highest level of K.

Tests growing the organism on media with varying amounts of K while maintaining the host at a constant K level, showed that K influenced the

parasite. At the lower level of K the fungus killed more plants than at the normal level.

These preliminary results suggest that potassium influences the parasite as well as the host.

Title: ALFALFA MANAGEMENT AND THE INCIDENCE AND SEVERITY OF DISEASE

Leaders: F. L. Lukezic and J. B. Washko, Pennsylvania

Field observations suggest that inoculum of Colletotrichum trifolii, which causes southern anthracnose, is spread by factors other than free water. Disease incidence pointed to harvesting equipment as a factor in fungal spread. Colletotrichum-infected stems, placed under conditions similar to those existing when plant debris is caught and moved about in harvesters, produced viable spores 60 days later. Fungal survival tests at different temperatures, using infected alfalfa stems show that the fungus can persist for three months when stored at ambient temperatures and over 5 months at 5 C. This information strongly suggests harvesting equipment is important in transmission of the causal agent and plant debris is important in pathogen survival.

Title: EFFECT OF DISEASE COMPLEX ON QUALITY COMPONENTS OF CORN GROWN FOR SILAGE

Leader: D. W. Allinson, Connecticut (Storrs)

The component parts of diseased (yellow leaf blight-stalk rot-corn borer complex) and relatively nondiseased corn plants, used by W. W. Washko in his yield study, were analyzed for quality parameters. The dried and ground fractions were analyzed for crude protein (CP), acid-detergent fiber (ADF), and acid-detergent lignin (ADL). The data are presented in the table on page 30.

Diseased fractions were higher in CP and ADF and lower in ADL and the ADL:ADF ratio than comparable nondiseased fractions. The magnitude of these differences, however, though consistent was not striking.

Percentage content of CP, ADF, ADL, and the ADL:ADF ratio in diseased and nondiseased corn fractions.

Plant fraction	CP		ADF		ADL		ADL:ADF	
	D*	ND**	D	ND	D	ND	D	ND
Tassels	6.6 [†]	6.5	45.7	44.7	8.1	8.1	0.18	0.18
Upper stem	3.2	2.6	51.9	47.5	7.3	7.4	0.14	0.16
Lower stem	5.1	3.9	55.6	51.1	9.5	10.8	0.17	0.20
Upper leaves	9.6	10.4	38.3	35.7	4.9	5.1	0.13	0.14
Lower leaves	9.9	9.4	41.2	40.4	5.4	5.4	0.13	0.13
Husks	4.4	4.1	42.6	40.8	3.8	4.4	0.09	0.11
Cobs	1.8	1.9	49.9	49.4	7.9	9.2	0.16	0.19
Grain	10.5	10.4	4.0	4.4	0.9	1.1	0.23	0.26
Mean	6.4	6.2	41.2	39.3	6.0	6.4	0.15	0.17

* D - Diseased

** ND - Nondiseased

[†] Each value is mean of six replicated samples.

Title: EFFECT OF DISEASE COMPLEX ON YIELD OF CORN GROWN FOR SILAGE

Leader: W. W. Washko, Connecticut (Storrs)

Severe leaf blighting was observed in our corn variety trials in 1969. On the basis of symptoms the disease was tentatively identified as yellow leaf blight but confirming pathological identification was not accomplished. Symptoms were observed initially on lower leaves, beginning on early varieties in late August, 1-2 weeks after silking. Spotting and subsequent leaf drying occurred rapidly up the plants. Only the very latest varieties or isolated plantings appeared to escape infection in the state.

Following the appearance of blight symptoms above the ear leaf occasional plants were observed to suddenly wilt and die. This phenomenon increased during maturation. At the time of harvest estimates of plants so affected were as high as 70% of the sample total. This premature death of

plants was attributed subsequently to stalk rots, the incidence of these associated with an extremely heavy infestation of European corn borers.

Twenty-five paired 6-ear samples were collected from killed and live plants in yield trials during late September. (Subsequently these plants are referred to as diseased and nondiseased; though this terminology is relative since nondiseased plants showed some blight symptoms but had not been killed at the time of sampling.) Wherever possible, the ears from each pair of samples were obtained from paired adjacent diseased and nondiseased plants. These ear samples were dried, shelled, and weights of cobs and grain determined. Ears, cobs, and grain from diseased plants weighed an average of 15.8, 11.9, and 17.2% less, respectively, than comparable fractions from nondiseased plants.

Similarly, six paired whole plant samples of six plants each were also collected, fractionated into component parts, dried, and weighed. Yield data are provided in the accompanying table. Yield depression due to premature killing was severe though plant fractions were differentially affected. The overall reduction in yield of diseased plants amounted to 14.9%.

Component yields of 6-plant sample.

Plant fraction	<u>Grams dry matter</u>		Percentage loss due to disease
	Nondiseased	Diseased	
Tassels	17.7	16.5	6.7
Upper stems	80.2	62.5	22.4
Lower stems	248.2	207.5	16.4
Upper leaves	195.0	166.2	14.8
Lower leaves	112.0	102.8	8.2
Husks	134.0	102.7	23.4
Cobs	161.8	147.5	8.8
Grain	808.3	690.3	14.6

Title: INVESTIGATIONS OF FORAGE CROP INSECTS IN MASSACHUSETTS IN
1969

Leaders: D. E. Miller and F. R. Shaw, Massachusetts

Population studies.--These investigations were carried on in Berkshire, Bristol, Essex, Franklin, Hampshire, Middlesex and Plymouth counties. The bulk of the data were obtained from collections made weekly in Hampshire County and biweekly in Berkshire County. Samples consisted of 100 sweeps with a 15-inch net per field. The insects were taken to the laboratory and determined. The data appear in the following table.

Populations of insects collected on alfalfa - 1969

Insect name or group	Percent of total insects	
	Hampshire County	Berkshire County
Leafminer (<u>Agromyza</u> sp.)	62.8	60.2
Pea aphid	21.6	12.7
Plant bugs	4.5	4.2
Tarnished plant bug <u>Lygus</u> sp.	2.4	1.6
Alfalfa plant bug	2.0	0.8
Meadow plant bug	0.1	0.8
<u>Capsus</u> spp.	*	0.2
<u>Trigonotylus ruficornis</u>	*	0.7
Meadow spittlebug	3.5	1.2
Alfalfa weevil	3.3	15.3
Adults	0.2	0.2
Larvae	3.1	15.1
Grasshoppers	2.3	4.1
Lepidopterous larvae	0.1	0.2
Sawfly larvae	0.1	*
Beneficial Arthropods		
Parasitic Hymenoptera	0.5	0.4
<u>Nabis</u> spp.	0.3	0.3
Spiders	0.3	0.6
Coccinellidae	0.1	0.2

* Less than 0.05%.

Adult Agromyza leafminers were the most abundant insect pest of alfalfa in both Berkshire and Hampshire counties. These insects were relatively rare early in 1968 but greatly increased during the 1969 season. Two species now known as Agromyza sp. and Liromyza sp. have been identified with the former being more abundant. Damage results from the mining of the larvae in the alfalfa leaflets. As many as 52% of the leaflets have been found infested, and county averages were 37.1% for Berkshire and 31.7% for Hampshire. The insects are multibrooded. Two parasites Clortocerus cinctipennis Ashm and Diglyphus pulchripes (Crawford) were reared from leaves infested by the leafminers.

The alfalfa weevil population continued to be relatively low in Hampshire County but in Berkshire it was second to the leafminers in abundance. This difference may be due to the fact that a greater number and more species of parasites have been released in Hampshire County.

Biological control.--Investigations have shown an overall increase in parasitism of the alfalfa weevil by Bathyplectes curculionis but a decrease by Tetrastichus incertus. Bathyplectes becomes active earlier in the season and prefers 1st and 3rd instar larvae for parasitization whereas Tetrastichus prefers 2nd to 4th instar larvae. However, neither of the parasites nor their combination reduces sufficiently the larval population of the alfalfa weevil in May or early June.

Experiments have shown that the golden eye lacewing larvae have little if any value as predators of alfalfa weevil larvae since they prefer to feed on aphids.

A serological method of determining predator-prey relationships is being investigated in an attempt to determine what the food preference of predaceous insects collected in alfalfa fields may be. Antibodies to common alfalfa pest insects have been produced in rabbits. Smears from field collected predators were made, dried over phosphorus pentoxide and stored in desiccator jars. The test is performed by reconstituting the predator smears in saline solution and utilizing the ring precipitin technique to check the gut contents of the predaceous insects against the alfalfa weevil larvae antibodies. Podisus maculiventris and P. placidus were successfully reared on alfalfa weevil larvae. Attempts to rear them on an artificial diet resulted in their development to the adult stage but they failed to reproduce.

Chemical control.--A study of the comparative insecticidal value and residual life of two formulations of Imidan on alfalfa has been completed. Against the alfalfa weevil Imidan proved to be more effective than methoxychlor and the wettable powder appeared to give a longer lasting control than did the emulsifiable formulation.

Title: EFFECTS OF SITONA HISPIDULA ON ALFALFA AND ALFALFA-ORCHARDGRASS MIXTURES

Leaders: R. C. Newton, R. R. Robinson, R. R. Hill, Jr., and C. F. Gross, Pasture Laboratory

Interrelationships between Sitona hispidula, alfalfa, and alfalfa-orchardgrass mixtures are being studied on the following four treatments: 1) alfalfa alone with no control of root insects, 2) alfalfa and grass with no control of root insects, 3) alfalfa alone with control of root insects, and 4) alfalfa and grass mixture with control of root insects. Root insects were controlled with dieldrin, which has been banned for use on forages since we applied it. The most prominent root insect was the larva of S. hispidula, but effects of other root insects could not be eliminated in this study. Control of root insects resulted in a lower percent of grass in the mixture in the third harvest, greater recovery after the first harvest, fewer S. hispidula larvae per plot, and less root damage due to feeding of S. hispidula larvae. Control of root insects had no effect on yield per se at any harvest, on total yield, or on root diameter in the first harvest year. The experiment will be continued to determine the long-term effects of root insects on alfalfa and alfalfa-orchardgrass mixtures.

Title: INSECTICIDE CONTROL OF ROOT-FEEDING INSECTS ON FORAGE YIELD AND ALFALFA ROOT GROWTH

Leaders: C. F. Gross and R. R. Robinson, Pasture Laboratory

Alfalfa recovery was significantly increased after the first harvest in field plots that had received insecticides (dieldrin, heptachlor) for control of root-feeding insects particularly Sitona hispidula (clover root curculio). Sixteen 20 x 20-ft plots of alfalfa and an alfalfa-orchardgrass mixture were seeded in the spring of 1968 and treated for root-feeders in late summer of 1968 and 1969. Soil cores taken from each plot to assess injury to alfalfa taproots between treated vs untreated plots showed no apparent damage the seeding year, but in the 1969 growing season alfalfa from the insecticide-treated plots had significantly less taproot injury and fewer S. hispidula larvae (alfalfa and mixture plots 11 and 13 larvae/ft², respectively) than alfalfa from the untreated plots (alfalfa and mixture plots 61 and 91 larvae/ft², respectively). There was an expected significant reduction in percent alfalfa when grown with orchardgrass at all harvests. In the third cut a significant interaction of orchardgrass with insecticide was obtained where dieldrin significantly increased the percentage of alfalfa in the mixture. Individual or total harvest yield per se did not approach significance.

Title: EVALUATION OF INSECTICIDES FOR ALFALFA WEEVIL CONTROL IN PENNSYLVANIA

Leader: A. A. Hower, Jr., Pennsylvania

Fourteen experimental chemicals were evaluated for control of the alfalfa weevil in Pennsylvania. Materials were applied at first egg hatch or when 25% or 50-75% of the alfalfa tips showed weevil larval feeding damage. None of the materials applied at the time of first weevil egg hatch gave adequate control. The most effective material tested was Furadan applied at a rate of 0.5 and 0.75 lb actual per acre when 50-75% of the alfalfa tips showed weevil larval feeding. These rates gave better than 99% control. Methyl parathion applied at 0.5 lb actual per acre when 50-75% of the alfalfa tips were damaged gave 93% control. Furadan applied at 0.5 and 1.0 lb actual per acre at 25% tip damage also gave better than 90% reduction in larvae at harvest. All other materials were less than 90% effective.

Alfatox, a registered compound, and GS-13005, an experimental material, were evaluated at various time intervals to harvest in western Pennsylvania. Alfatox at 3 qts and GS-13005 at 0.5 and 1.0 lb actual per acre applied at 14 and 7 days before harvest caused a statistically significant reduction in weevil larval populations until harvest. Populations on nontreated plots averaged 196 larvae per sweep at harvest.

A spray schedule consisting of two selectively timed applications on the first crop was compared with 1) one insecticide application on the first crop two weeks before harvest followed by a stubble spray, 2) one application on the first crop as in 1) above, but no stubble spray and 3) stubble spray only. Due to low level larval infestations these spray schedules, although reducing populations significantly over the nonsprayed plots, could not be evaluated sufficiently.

Title: APPLICATION OF ENERGY FOR CONTROL OF INSECTS

Leaders: W. L. Harris, N. A. Clark, J. W. Neal, University of Maryland; and R. H. Ratcliffe, ARS, USDA

The desirability of obtaining data and experience on field size plots resulted in a program of cooperative work with two Maryland alfalfa growers. The objective of the program, in addition to flaming of fields and plots on Maryland's Forage Research Farm, was to obtain farmer evaluation of flaming as a means of weevil control and to develop data to use in an economic analysis of flaming.

Dormant flaming provided effective weevil control in two locations, but in one location the cooperator sprayed one field prior to first cutting. Stubble flaming provided effective weevil control in all locations.

Flame treatment resulted in higher quality alfalfa. Protein content of material from fields flamed was approximately 10% greater than spray treated material.

The experimental flamer used to apply treatments demonstrated cost economics competitive to insecticide spray treatments. In addition, cooperators stated that flaming reduced management decisions and anxiety normally experienced with insecticide mixing, sprayer calibration, application and dispersion.

Title: FURTHER STUDIES ON THE STERILIZATION OF THE ALFALFA WEEVIL

Leaders: A. A. Hower, Jr. and F. R. Ferrer, Pennsylvania

Previous studies have shown that 3000 to 4000 rads of gamma radiation induce sterility in the male alfalfa weevil.

The present investigation has shown that female weevils irradiated with doses of 2500 to 4500 rads exhibited reductions in fecundity and egg viability. Doses of 3000 rads applied to 3-week-old females caused a 6-fold reduction in fecundity during the first month of oviposition and approximately 4-fold reduction during the third month. Viability of eggs produced by these females was 62.0 and 31.0%, respectively, when mated with nonirradiated males. However, at the highest dose (4500 rads) used the total number of eggs oviposited by a female was reduced by 99.3% and egg viability ranged from 10 to 33%. However, these latter percentages represent only a very small number of eggs observed per female.

Females irradiated at 4 weeks of age exhibited 45.4 and 36.8% egg viability for the first and third month of oviposition, respectively. At this age 4500 rads gamma radiation reduced egg viability to 0% for the first month and 8.2% during the third month of oviposition. Likewise, fecundity was reduced to 90 and 82%, respectively, for both periods of observation. Nonirradiated males and females as well as males and females irradiated with 4500 rads at 4 weeks of age showed similar mortality.

In a supplementary study multiple mating experiments were conducted by confining 6-week-old females with nonirradiated males and the same group of females was later mated with irradiated males (3500 rads). Eggs collected after the first mating showed 94.0% viability. However, viability was reduced to 3.2% following the second mating. Reciprocally nonirradiated females mated first with irradiated males and secondly with nonirradiated males, exhibited 0 and 81% egg viability after the respective matings.

Title: CUTTING AND SPRAY MANAGEMENT IN ALFALFA WEEVIL CONTROL

Leaders: R. R. Hill, Jr. and R. C. Newton, Pasture Laboratory

Four alfalfa varieties were subjected to different management and spray treatments in a study to obtain information on methods of growing alfalfa in the presence of the alfalfa weevil. Cherokee, Iroquois, Saranac, and Vernal were subjected to early cut-no stubble spray, early cut-stubble spray, normal cut-no stubble spray, and normal cut-stubble spray in the 1967 test; and Cherokee, Saranac, Vernal, and Team were subjected to early harvest-no spray, early harvest-stubble spray but no foliar spray, normal harvest-no control, normal harvest-foliar spray-no stubble spray, normal harvest-foliar and stubble spray, and normal harvest-control with systemic insecticide. Foliar sprays were applied to the normal harvest treatments (except no-control treatment) at the time of the early cut (May 28). Significant differences were not observed for management effects for two reasons: 1) weevil populations were too low to affect yield significantly, and 2) second and third harvests on all treatments were taken on the same day, giving approximately 2 weeks longer growing time between first and second harvests on the early-cut managements. Significant differences were observed among varieties. Two-year average yields were 4.59, 5.00, 5.16, and 4.56 tons per acre for Cherokee, Iroquois, Saranac, and Vernal, respectively, in the 1967 study; 1969 yields were 4.81, 4.91, 4.79, and 5.01 tons per acre for Cherokee, Saranac, Vernal, and Team, respectively, in the 1968 test.

Title: ALFALFA WEEVIL DEVELOPMENT AND CONTROL AS RELATED TO ENVIRONMENTAL CONDITIONS

Leaders: G. G. Gyrisco, C. C. Lowe, B. E. Dethier, M. J. Wright, and R. F. Lucey, Cornell

Each of 25 locations throughout New York were sampled once or more often per week from May to September with standard sweep net for adults and larvae of the alfalfa weevil. Samples of live weevils were also taken and reared weekly for parasites. Other data on plant development, air and soil temperatures were also recorded at some of the locations to be correlated later with plant and weevil development vs infestation in a computer analysis.

Inspection of data for 1968 and 1969 indicates that weevil populations are in a sharp decline in the lower Hudson Valley, are dropping in the Southern Tier, are still quite stable in west central New York and continue to be on a rise in areas of very recent infestation such as Steuben and Niagara counties. Little chemical treatment of weevils was done in the lower Hudson Valley in 1969.

Microctonus aethips has been recovered from earlier releases in New York in 1968 and Bathyplectes curculionis continued to spread and assume a more important role in weevil control. Tetrastichus incertus is throughout the state and its impact is greater on the midsummer larval populations. Additional releases of Bathyplectes contractus and B. curculionis were made in 1969.

Title: FLIGHT BEHAVIOR AND DIRECTION OF MIGRATING ALFALFA WEEVILS

Leaders: G. G. Gyrisco and J. A. Sherburne, Cornell

Various types of traps and cages were constructed to supply flight information. The traps were predominately used with Stickem Special to form sticky boards or sticky screens. Some were 10 x 10 x 15 ft high.

Some weevils crawled to the tops of screens and flew on their first attempt. Others took repeated short hops and flights into the ground or returned to the ground by crawling. There may be an optimum range of wind speed necessary for maximum success in flight and dispersal.

Compass direction and distance from woods did not influence pre-flight orientation or flight direction.

Title: GRASSLAND INSECT INVESTIGATIONS

Leaders: S. R. Race and B. B. Pepper, New Jersey

Economic alfalfa weevil populations failed to develop in most New Jersey alfalfa fields during 1969. A survey conducted in 1967 determined that 94% of all growers (dairymen) applied insecticidal sprays for weevil control. In 1968, the survey showed that only 45% applied controls, and in 1969, only 10% controlled.

It is clear now that the reason for this significant decline was the activity of a complex of parasitic wasps originally introduced from Europe by USDA entomologists at Moorestown, and spread throughout New Jersey by our State Department entomologists. This is one of the rare instances of biological control effectively reducing an economic pest in New Jersey.

The best available evidence indicates that weevil populations will continue to be checked by parasites and therefore remain a minor pest in New Jersey.

The northern corn rootworm was first discovered in New Jersey near Phillipsburg in September 1967. Since then it spread rapidly to every corner of the state but is especially numerous in Warren, Hunterdon and Somerset counties. To help determine the economic significance of this pest on field corn, several tests will be set out in 1970.

The cereal leaf beetle, a serious pest of cereals in the midwest, has not been collected yet from New Jersey, although it was found as close as Bucks County, Pa. during 1969.

Title: INTEGRATED ALFALFA PEST CONTROL

Leader: C. K. Dorsey, West Virginia

Experiments were conducted at West Virginia University to facilitate the total production of the important crop, alfalfa. These researches concerned the control of insects and weed pests.

Twelve different (primarily herbicidal) weed control treatments were applied. These treatments were made November 25, 1968, on half of the replicated plots and March 18, 1969, on the other half of each plot. The treatments were applied as separate chemical sprays and in combination with LP-gas flaming. Flaming alone was used as one treatment. The chemical herbicides used were: Karmex, Simazine, Tergacil, 2-4 DB and CIPC. All were applied at 1 lb actual/acre except Karmex, which was used at the 3 lb/acre rate. The results showed that all of the treatments gave economic control (78-92%) of the alfalfa weevil larvae and also good control of several of the more important weed pests of alfalfa such as yellow rocket, plantains, and orchardgrass.

Title: SURVEY OF NORTHERN CORN ROOTWORM AND CEREAL LEAF BEETLE POPULATIONS IN NEW YORK

Leaders: G. G. Gyrisco and J. A. Sherburne, Cornell

During August 5, fields in each of six corn counties were surveyed for northern corn rootworm. A total of 600 plants were randomly examined in each field for visible damage and for adults while the soil beneath 10 plants was dug up and hand sorted for immature stages. Counts of beetles were generally less than 10/200 plants and visible damage attributed to the insect was seen in only one field (Cayuga County) which had not been rotated for a number of years.

Cereal leaf beetles were found in oats in 10 counties of western and central New York. No economic loss was present in any case. The infested fields were in the following counties: Allegany, Cattaraugus, Chautauqua, Erie, Genesee, Monroe, Ontario, Orleans, Steuben and Wyoming. These counties are in western and west central New York.

Section III

Variety Performance, Production, Management,
Weed Eradication, Engineering, etc.

Title: INFLUENCE OF SOIL pH AND FERTILIZER APPLICATIONS ON NUTRIENT UPTAKE, NUTRIENT REMOVAL, SOIL TEST LEVELS AND ALFALFA YIELDS

Leader: R. L. Flannery, New Jersey

This study was designed to provide information on the combined effects of soil pH and fertilizer applications on yields of Atlantic alfalfa grown on Freehold sandy loam soil. Data are being obtained (not reported) on the nutrient content of alfalfa at the early bloom stage for each harvest. Changes in soil test levels as affected by lime and fertilizer treatments and nutrient removal by alfalfa harvests are also being obtained.

Experiment was established in the spring of 1967. Experiment was designed to study soil pH values of 5.0, 6.0 and 7.0, annual phosphate (P_2O_5) applications of 0, 75 and 150 lb per acre, annual potash (K_2O) applications of 0, 150 and 300 lb per acre and annual boron (B) applications of 0 and 3 lb per acre. Experimental design: 3 pH values X 3 P_2O_5 rates X 3 K_2O rates X 2 B rates X 4 replications. pH values were established in the main plots prior to seeding the alfalfa and have been maintained. Fertilizer nutrients have been applied annually to subplots within the main pH blocks.

Plots were harvested twice in 1967, four times in 1968 and four times in 1969. Yield data obtained in 1969 along with soil test levels at the start of the experiment are reported (see table next page).

Influence of phosphorus, potassium and boron application at three pH values on yield of alfalfa on Freehold sandy loam soil at Adelphia, N.J. in 1969.

Pounds per acre			Alfalfa yields, pounds dry matter per acre			
P ₂ O ₅	K ₂ O	B	pH 5.0	pH 6.0	pH 7.0	Average
0	0	0	5,681	10,449	10,115	8,748
0	0	3	7,461	10,494	11,197	9,717
75	0	0	7,597	10,803	11,514	9,971
75	0	3	8,833	11,021	11,880	10,578
150	0	0	9,494	11,043	12,309	10,949
150	0	3	10,523	11,877	12,162	11,521
0	150	0	5,700	11,584	13,176	10,153
0	150	3	6,968	11,105	12,411	10,161
75	150	0	10,046	12,078	13,351	11,825
75	150	3	11,515	12,107	13,398	12,340
150	150	0	11,022	11,857	13,268	12,049
150	150	3	12,018	12,966	13,516	12,833
0	300	0	8,971	10,860	12,424	10,752
0	300	3	8,663	12,142	12,586	11,130
75	300	0	9,168	11,545	13,596	11,436
75	300	3	9,542	12,635	14,007	12,061
150	300	0	9,435	12,986	14,202	12,208
150	300	3	11,976	13,341	13,004	12,774
--	--	0	8,568	11,467	12,661	10,899
--	--	3	9,722	11,965	12,685	11,457
0	--	--	7,242	11,106	11,985	10,111
75	--	--	9,450	11,698	12,958	11,369
150	--	--	10,745	12,345	13,077	12,056
--	0	--	8,265	10,948	11,530	10,248
--	150	--	9,545	11,950	13,187	11,561
--	300	--	9,626	12,252	13,303	11,727
--	--	--	9,145	11,717	12,673	11,178

Soil test values for pH, phosphorus, potassium and boron in alfalfa plots in spring 1968 just prior to initiating lime and fertilizer treatments.*

Treatment lbs/acre		Phosphorus, lbs/acre			Potassium, lbs/acre		
P ₂ O ₅	K ₂ O	pH 5.5	pH 6.0	pH 6.5	pH 5.5	pH 6.0	pH 6.5
0	0	62	71	65	92	95	97
75	150	104	98	101	127	110	135
150	300	152	145	144	174	145	155

* Water soluble boron averaged 0.40 ppm.

Title: FACTORS THAT INFLUENCE ALFALFA SURVIVAL ON SLOPING FRAGIPAN
 SOILS OF THE NORTHEAST

Leaders: G. R. Benoit and J. Bornstein, Vermont (ARS in cooperation
 with the Vermont Agricultural Experiment Station and the
 U.S. Soil Conservation Service)

Alfalfa has continued to be used as an indicator crop in a wet sloping land research drainage project. The winterkill during the second winter after planting was found to be 66, 47, and 43% for the no subdrain, subdrain at 200 ft spacing, and subdrain at 100 ft spacing plot, respectively. Results continue to indicate that the better drained plots maintain the healthiest, most vigorous plant population with lowest overwinter injury and death.

Title: GROWTH RESPONSES OF CORN AND ALFALFA TO SOIL FERTILITY AND
 IRRIGATION

Leader: N. A. Clark, Maryland

This study compared corn silage, corn grain, double crop corn silage-wheat silage, and alfalfa under three irrigation regimes. The irrigation regimes were: no irrigation, subsurface irrigation, and overhead irrigation. Each crop under each irrigation regime received three different fertilizer levels: half soil test requirement, soil test requirement, and double soil test requirement. Results to date show corn responds favorably to both subsurface and overhead irrigation. As expected, there was little or no response in years with favorable rainfall and a large response in drought years. The beneficial effects of irrigation were most evident in the double crop corn following a dry year in which the winter small grain was depleted. Alfalfa performed poorly under irrigation. Under overhead irrigation leaf diseases and weed encroachment were severe. With subirrigation saturated soil conditions in some parts of the plots caused noticeable yellowing and stunting of the plants. The fertilizer response has been greatest with corn under irrigation, but with alfalfa there has been a fertilizer response irrespective of irrigation.

Title: ALFALFA VARIETY PERFORMANCE EVALUATIONS

Leaders: J. A. Schillinger and T. E. Divine, Maryland

Forage yields in 1969 were significantly different for five alfalfa varieties seeded in April 1967. Team produced the highest yield (7.35 tons per acre) in 1969. Other varieties in the test and their 1969 yields were Cherokee (6.59), Saranac (6.28), Iroquois (6.34) and Vernal (6.28). Team's superiority was attributed mainly to its resistance to several disease organisms, particularly southern anthracnose, and common and Stemphylium leafspots. These diseases were believed responsible for the serious stand depletions in all varieties except Team.

Seeding-year forage yields for 20 alfalfa varieties including 15 proprietary varieties ranged from 4.70 to 4.16 tons per acre. Southern anthracnose was prevalent in this study in July and August and caused as much as 32% loss in stands from July to September.

Title: MANAGEMENT EFFECTS ON PRODUCTIVITY, PERSISTENCE AND QUALITY OF ALFALFA

Leader: J. B. Washko, Pennsylvania

Four of 32 alfalfa varieties, Saranac, Waterman-Loomis 210, 303 and 305, continue to maintain stands and excel in forage production when harvested at the dehydration stage (late bud) and early hay stage (sprinkle of blossom to 1/10 bloom) in the fourth harvest year. Only those varieties with bacterial wilt resistance have survived to date.

For maximum dry matter production harvest frequencies of 40 days or longer are required. Highest protein and TDN content are obtained on a 30-day harvest schedule but yields are low. The best compromise on quality and yield was achieved with a 35-day harvest schedule. For each 5 days that harvest frequency was lengthened beyond 30 days, a half ton yield increase was obtained up to 40 days. The most critical harvest period for survival of alfalfa into the next year is that taken the last week in August and where this one is followed by another after a killing frost.

No yield response in alfalfa was obtained on a fertile soil from either nitrogen or micronutrients. Potash applications of 120 lb K₂O per acre were insufficient to maintain high production; 240 lb K₂O per acre per season were required or yields decreased 1.1 tons in the third harvest year.

Title: GRASS EFFECTS IN ALFALFA-GRASS MIXTURES

Leaders: C. S. Brown and R. F. Stafford, Maine

A study was begun to determine the role of timothy in alfalfa stands, its potential contribution to total forage yields, and its effect on winter survival of alfalfa.

Differential stand densities of Iroquois alfalfa were obtained through alfalfa seed rates ranging from 2 to 18 lb per acre. Each stand density treatment was split-plot with Climax timothy, providing a comparison of pure alfalfa vs alfalfa-timothy at each density.

Two harvests were obtained in the 1969 seeding year. Alfalfa yields ranged from 1.1 to 2.5 tons dry matter per acre with increasing alfalfa seed rate. The inclusion of timothy had no significant effect on alfalfa yields. Timothy yields ranged from 0.4 tons in the 2-lb alfalfa seeding to 0.1 tons in the 18-lb seed rate. The study will be continued in 1970, and will include a nitrogen fertilization treatment.

An established study was continued, comparing pure stands of Saranac alfalfa vs mixtures of Saranac + Saratoga brome and Saranac + Pennlate orchardgrass. Total yields were increased 0.21 ton and 0.46 ton by inclusion of brome and orchardgrass respectively. Alfalfa yields were suppressed slightly by associated brome and greatly by the orchardgrass.

Title: PRODUCTIVITY OF ALFALFA-RED CLOVER MIXTURES

Leaders: C. S. Brown and R. F. Stafford, Maine

The study sown in 1968 was continued (p. 42, 1968 Report). Mixtures of alfalfa and red clover were compared to single-legume stands of alfalfa and red clover. Comparisons were made under both 2-cut and 3-cut harvest systems.

Dry matter yields for the 1969 season are briefly summarized in the following table. These are given as varietal means of Saranac-Iroquois and Pennscott-Dollard. The alfalfa-red clover mixtures were nearly as productive as alfalfa alone. Alfalfa dominated in each of these mixtures. Pure stands of red clover were distinctly inferior to alfalfa and alfalfa-red clover mixtures.

Mean yields of two alfalfa-red clover mixtures in comparison to their respective single legume stands.

Legume species*	Dry matter, tons per acre					
	2-harvest system			3-harvest system		
	Alfalfa	Clover	Total	Alfalfa	Clover	Total
Alfalfa alone	4.50	--	4.50	4.16	--	4.16
Red clover alone	--	3.22	3.22	--	3.34	3.34
Alfalfa + red clover	3.24	1.10	4.34	3.20	0.82	4.02

* Saranac in mixture with Pennscott; Iroquois with Dollard.

Title: MANAGEMENT EFFECTS ON MORPHOLOGY AND PHYSIOLOGY OF TIMOTHY AND REED CANARYGRASS

Leaders: J. B. Washko and Paul Mislevy, Pennsylvania

Forage productivity of Climax timothy was evaluated under two systems of harvest management with the following results: 1) Highest total season dry matter yield, 4.77 tons per acre, was obtained when the first harvest was taken at a plant height of 12 to 14 inches followed by a second harvest 7 weeks later and third and fourth harvests at 4-week intervals, 2) removal of the first harvest at the boot stage, followed by recovery periods of 7- and 4-week intervals increased forage yields by approximately 1/2 ton per season. A cutting height of 1 1/2 inches imposed on both reed canarygrass and Climax timothy not only resulted in higher forage yields but kept quackgrass under control whereas under the 3 1/2 inch cutting height quackgrass competed so severely with the seeded species as to reduce their stand.

Reed canarygrass produced lowest seasonal forage yields and less TDN when the initial harvest was removed at plant heights of 8 to 12 inches. Reed canarygrass was less influenced by initial cutting height than was Climax timothy. These results indicate that different grass species do not respond the same to harvest management systems.

Title: MANAGEMENT OF ANNUAL FORAGE SPECIES FOR QUALITY FORAGE

Leader: J. B. Washko, Pennsylvania

Forage production of 13 sorghum-sudangrass hybrids, 3 sudangrass hybrids, one open-pollinated sudangrass variety and 6 corn hybrids was followed at 4 locations in the state. Corn outyielded all other summer annuals at two of the four locations. Only 4 varieties of sorghum-sudangrass hybrids, Mor-Su 2, Sudum, Greenlan and Lindsey 78F exceeded 7 tons of dry matter per acre, whereas 4 of the 6 Pa. corn hybrids, 450, 510, 602A and 604, exceeded this yield. HS-33 and Monarch sudangrass hybrids outyielded open-pollinated Piper sudangrass by 2.1 tons of dry matter per acre.

These results indicate that farmers interested in maximum yields of dry matter per acre for either green chop or ensilage should grow adapted corn hybrids. For grazing purposes HS-33 and Monarch sudangrass hybrids should be chosen in preference to the Piper variety.

Title: SELECTION AND MANAGEMENT OF FORAGE SPECIES FOR HORSES

Leaders: T. L. Merritt and J. B. Washko, Pennsylvania

In the second year of grazing a mixture of Kentucky bluegrass, Saratoga brome grass, and Climax timothy fertilized with two 50-lb increments of nitrogen, one in early spring, the other in midsummer, produced highest dry matter yields. The same grass mixture with Vernal alfalfa produced only slightly less forage per season. Lowest yields were obtained from Viking birdsfoot trefoil seeded with the same three grasses. When three split applications of 50 lb each of nitrogen were applied on a Ky. bluegrass-smooth brome grass-timothy mixture no increase in forage yields was obtained.

The alfalfa-three grass mixtures furnished 176-horse days of grazing in four rotational grazings. Paddocks fertilized with 150 lb of nitrogen furnished 160-horse grazing days per season compared with 146 days where 100 lb of nitrogen were applied. The birdsfoot trefoil-three grass mixtures was lowest in carrying capacity, furnishing only 118-horse days of grazing. Horses made satisfactory growth and had a desirable amount fleshing under all grazing regimes.

Mixtures in small plots produced four tons or more of dry forage per acre during the third harvest season indicating that horse owners have a wide choice in the selection of forage mixtures for horse pastures.

Title: INFLUENCE OF DATE AND METHOD ON THE FALL ESTABLISHMENT OF ALFALFA AND BIRDSFOOT TREFOIL

Leader: D. W. Allinson, Connecticut (Storrs)

This experiment was initiated to establish (a) the final 'safe' date for seeding alfalfa and birdsfoot trefoil in Connecticut, and (b) the influence of method of seeding upon the fall establishment of these forages.

Saranac alfalfa and Viking birdsfoot trefoil were seeded on the following dates in 1968: July 23, August 14, September 4, and September 16. Two methods of seeding were used, i.e., band seeding with press wheels and broadcast seeding. Alfalfa was seeded at 12 lb/acre, birdsfoot trefoil at 6 lb/acre. In 1969 three harvests of alfalfa were taken while only two of birdsfoot trefoil were possible.

Analysis of variance indicated that the date of seeding, species, and species x date of seeding effects were significant ($P < 0.01$). There was no significant difference between the two methods of seeding. The data would suggest that fall seeding of trefoil under Connecticut conditions to be ill-advised. Seedings of alfalfa up to early September are possible, yields in the following year averaged 4.4 tons DM/acre. However, seeding of alfalfa in late July produced yields of 5.4 tons DM/acre in the following year.

Title: PRODUCTIVITY AND QUALITY OF FERTILIZED PERENNIAL FORAGES

Leader: L. F. Marriott, Pennsylvania

Crownvetch fertilized with P and Mg in 1968 at four locations was harvested once in 1969. Yields ranged from 0.5 to 1.8 tons per acre. There appeared to be more quackgrass where two harvests had been made in 1968 than where only a fall seed harvest had been made that year. Volunteer red and white clover provided much competition for the 1968 crownvetch seeding at the Agronomy Farm. A July harvest indicated no yield differences resulting from P rates at seeding. Combinations of N, P, K, Mg and trace elements were applied for the 1970 crop. Where crownvetch was seeded with grasses, there was a lower proportion of crownvetch in the brome grass and orchardgrass associations than in the timothy-fescue association.

Analyses of 1968 soil samples taken from plots established on low Mg soils (Indiana County) in 1966 indicate that Mg applications generally increased the soil Mg in relation to the rate applied. Addition of calcitic limestone usually lowered the exchangeable Mg. In plowed

soils, the effectiveness of dolomitic limestone as a contributor to soil Mg increased with time. When topdressed on pasture fields, most of the Mg applied as Alcan magnesia was accounted for in the 0"-2" soil sample, and 10 to 20% in the 4"-6" sample. Topdressed dolomitic limestone contributed considerably less to the exchangeable Mg at both sample depths. Plant tissue samples in 1968, as in 1967, showed that high rates of Mg must be applied to effectively increase the Mg content of plants.

Title: RELATIONSHIP OF NODULATION TO STAND ESTABLISHMENT IN
 CROWNVETCH (CORONILLA VARIA L.)

Leaders: P. M. Halisky, R. W. Pace, and R. W. Duell, New Jersey

This study was designed to evaluate some of the factors associated with stand establishment in crownvetch. Field comparisons of Chemung, Penngift, and Emerald crownvetch indicated that Chemung was superior in seedling vigor and stand establishment. Plant size, vigor, and foliage color were, in turn, related to the degree of effective nodulation by Rhizobium. Nodulation was reduced when inoculated seed was pelleted with lime or treated with Arasan or Ceresan fungicides.

Nodulation appeared to be a key factor in the establishment of hydro-seeded crownvetch along New Jersey highways. The data in the table show that 60 plants growing in sparse stands were almost devoid of nodules (avg. 0.03 nodule/plant) as compared with 30.7 nodules per plant growing in adjacent dense stands. Results of soil analyses for both sites were not appreciably different. In addition to being effectively nodulated plants growing in dense stands were more vigorous, being approximately three times taller than those growing in sparse stands. The general conclusion was that plant height, shoot number, plant vigor, foliage color, and stand establishment were all related to the degree of effective nodulation in crownvetch.

Comparative size and degree of nodulation of Penngift crownvetch plants selected from sparse and dense stands along highway embankments in New Jersey.*

Stand location	Sparse stand		Dense stand	
	Shoot length (inches)	Nodule number (inches)	Shoot length	Nodule number
U.S. Highway 1	9.3	0.1	26.3	23.7
Interstate 287	11.0	0.0	36.3	33.8
U.S. Highway 9	13.2	0.0	37.4	34.5
Overall average	11.2	0.03	33.3	30.7

* Tabular data are averages of 20 plants each. Overall averages combine data from 60 plants.

Title: ESTABLISHMENT, CULTURE AND MANAGEMENT OF FORAGES

Leader: M. A. Sprague, New Jersey

A prototype truneated pyramid 6 ft high was fitted with thermocouples and soil and air temperatures recorded during spring and summer. Air temperatures 1 inch above the soil surface in a bluegrass sod in May varied in excess of 40 F between east and west facing slopes at 8 AM EST, with north and south facing slopes 25 F below that facing east. By noon, air temperatures on the south-facing slope reached 110 F and all slopes cooled at a slower more constant rate in the afternoon than they had heated. Yield of grass on the south slope exceeded that facing north by a factor of 4 times in spring but was less in summer and fall. Soil moisture content in November on the north slope was twice that of the other exposures.

Title: INFLUENCE OF RATE AND TIME OF APPLICATION OF N AND K₂O ON
SILAGE CORN YIELDS, NUTRIENT CONCENTRATION IN EAR LEAF AND
HARVESTED SILAGE AND RESIDUAL NUTRIENT LEVELS IN THE SOIL

Leaders: R. L. Flannery and J. W. Paterson, New Jersey

This study was designed to provide information on time and rate of application of N and K₂O for silage corn production on sandy loam soils in New Jersey.

Yield, nutrient uptake and soil test data are being obtained for applications of N and K₂O at rates of 0, 50, 125 and 275 lb per acre applied broadcast in December, March and early May. All plots are receiving 25-25-25 lb of N-P₂O₅-K₂O per acre banded at planting time.

This experiment was established in the fall of 1967 and spring of 1968. The duration of the experiment is expected to be three years.

The influence of rate and time of application of nitrogen on silage corn yields are reported in Table 1. Silage yields were increased by increasing broadcast nitrogen application rates from 0 to 275 lb per acre. Yields were generally better when the nitrogen was applied in March or May as compared to the earlier application date of December, particularly at the lower rates of application. Time of application of nitrogen had little or no influence on yields at the higher rates of application.

Influence of rate and time of potash applications on silage corn yields are reported in Table 2. Rate or time of application of potash had little or no influence on silage corn yields in this experiment. Soil test levels were medium to high in the soil at the time the experiment was established.

Influence of nitrogen, phosphate and potash applications on yields and value of silage corn grown on Freehold sandy loam soil in 1968-1969 are reported in Table 3. Yield data reported in this table are averages for the three dates of fertilizer application for the two years of the study.

Table 1. Influence of rate and time of application of nitrogen on silage corn yields on sandy loam soil at Adelphia, N.J.

Nitrogen applied (lbs/acre)		Date broadcast N was applied					
		December		March		May	
		Tons of silage harvested per acre					
Br.*	B.**	1968	1969	1968	1969	1968	1969
0	25	21.6	24.8	21.8	26.2	23.1	26.1
50	25	24.4	27.0	24.4	28.4	27.1	29.1
125	25	27.4	29.2	29.1	30.1	28.7	30.3
275	25	31.8	30.3	32.8	32.3	31.7	29.4

* Br.= Broadcast before planting.

** B. = Banded at planting time.

Table 2. Influence of rate and time of potash applications on silage corn yields on sandy loam soils at Adelphia, N.J.

Potash applied (lbs/acre)		Date broadcast K ₂ O was applied					
		December		March		May	
		Tons of silage harvested per acre					
Br.*	B.**	1968	1969	1968	1969	1968	1969
0	25	26.0	27.2	26.6	29.8	25.8	28.5
50	25	26.0	27.7	27.1	29.0	26.6	28.6
125	25	26.9	28.0	27.9	29.8	29.0	28.9
275	25	26.4	28.3	27.1	29.2	28.3	29.0

* Br. = Broadcast before planting.

** B. = Banded at planting time.

Table 3. Influence of nitrogen, phosphate and potash applications on yields and value of silage corn grown on Freehold sandy loam soil in 1968-1969.

Plant nutrients applied*			Yields† tons/acre 75% moisture	Percent yield increase	Value of yield increase‡
N	P ₂ O ₅	K ₂ O			
0	0	0	20.95	0	--
25	25	25	21.75	3.7	\$ 1.20
25	150	25	23.17	9.6	3.98
75	150	75	24.52	10.5	8.13
150	150	150	30.18	30.6	48.07
300	150	300	31.87	34.2	39.28

* Plant nutrients valued at 10¢, 8¢ and 6¢ per lb. of N, P₂O₅ and K₂O, respectively.

† Silage corn valued at \$9.00/ton.

‡ Value of yield increase over check after deducting cost of fertilizer nutrients.

Title: EFFECT OF FERTILIZER MANAGEMENT ON NO-TILLAGE CORN PLOTS

Leaders: R. A. Peters and W. L. Currey, Connecticut (Storrs)

The experimental area was an old sod of bluegrass, bentgrass, and orchardgrass which had not been plowed for many years. It was top-dressed with 4000 lb of lime on April 29, 1969. On May 2, 1969 half of each replicate was plowed. Fertilizers from two sources were used, granular 15-15-15 and liquid 8-8-8. The rate was 210 lb N, 210 P₂O₅, and 210 K₂O/acre from both sources. Each fertilizer was initially broadcast. On the plowed blocks half of each block was lightly disked to incorporate both the granular and liquid fertilizers. The no-tillage blocks were sprayed as the corn was planted on May 29, 1969 with 1/2 lb ai/acre paraquat with X-77 wetting agent, 2 lb ai/acre atrazine and 1 lb ai/acre Lasso. A starter fertilizer of 200 lb/acre 10-34-0 was banded as the corn was planted. Wisconsin 335A was planted at a rate of 28,000 plants/acre in 34-inch rows. The stands actually obtained were 28,400 plants/acre in the plowed blocks and 27,300 in the no-tillage blocks. The yields were based on samples cut on September 12, 1969 when the ears were in the dent stage (see following table).

Fertilizer management	Corn silage yields - tons/acre 30% dry matter						Overall avg.
	Liquid fertilizer			Granular fertilizer			
	On surface	Inc.	Avg.	On surface	Inc.	Avg.	
Plowed plots	14.6	14.7	14.6	13.6	16.1	14.8	14.8
No-tillage plots	13.9			17.3			15.6
<u>Corn height measurements in feet</u>							
Plowed plots	2.0	2.3		2.0	2.4		
No-tillage plots	2.6			2.7			

The overall difference in yields between the plowed and the no-tillage plots was essentially nil.

There was no overall difference between liquid and granular sources of fertilizer on the plowed plots. There was a distinct advantage in the no-tillage plots in favor of the granular fertilizer as compared to the liquid. The combination of no-tillage with granular fertilizer gave the best yields in the experiment.

At the time the height measurements were taken early in the season the no tillage corn was the tallest, with the incorporated plowed plots next in order. By the end of the season, however, the differences in height were no longer evident.

Title: ON FARM COMPARISONS OF CONVENTIONAL AND NO-TILLAGE SILAGE CORN PRODUCTION

Leaders: R. A. Peters and W. L. Currey, Connecticut (Storrs)

Comparisons at 19 locations were made of silage corn grown by conventional (plow-disk-seed) and no-tillage (chemical kill-seed) methods. Sites included perennial grass sods and corn stubble land seeded to a rye cover crop. Corn planting and herbicide spraying were done in a single application using an Allis Chalmers No-Til Series 600 corn planter. The herbicide treatment was paraquat 1/2 lb ai/acre plus wetting agent, atrazine 2 lb ai/acre and alachlor 1 lb ai/acre. Kill of rye and sod species was excellent except for alfalfa and dandelion in the sod. At those locations where quackgrass was prevalent, there was considerably less regrowth in the no-tillage plots than in the

conventional plots. The averages for all locations indicated no differences in stand (27,000 plants/acre) nor in yields (17.5 tons/acre 30% dry matter) between no tillage and conventional methods.

Title: INFLUENCE OF SOD SPECIES IN NO-TILLAGE CORN PRODUCTION

Leaders: R. A. Peters and W. L. Currey, Connecticut (Storrs)

Atrazine-paraquat mixtures (atrazine 1 lb ai/acre plus paraquat 1/2 lb ai/acre) were applied to 11 different sod crops under 3 managements. Applications were made 1) on April 25 prior to seeding of corn on May 13; 2) at the same time corn was planted, May 13, in the standing crops and 3) on June 4 after removing a grass silage crop. Good kill was obtained of all species in April when growth was starting. Applications made in May when most sod species were heading out or in June after removing a silage cut gave incomplete control of alfalfa, orchardgrass and tall fescue. A broadcast application of 1000 lb/acre of 15-15-15 was made on May 1. A starter of 200 lb/acre of 10-34-0 was banded at planting.

The no-tillage planter with a fluted coulter used in this experiment planted the corn adequately in all of the sod species, judged by stand counts. Emergence of corn in the plots with a dead residue was delayed several days because of lower soil temperatures.

Yields of the corn planted in May were comparable between sod species. There was no significant difference between yields of corn planted in sod and in the nonplowed, nonseeded plot. When corn was planted in June after a grass silage crop was removed there were differences in yields. Since the significantly greater yields were all associated with legume plots, it was assumed that residual nitrogen was available to the corn. The legume effect was also reflected in the greater height of the corn early in the season.

The yields of the June planted corn were considerably lower than the May planted corn but the grass silage crop obtained compensated for the decrease.

Title: THE CONTROL OF WEEDS FOR PASTURE AND FORAGE PRODUCTION

Leader: C. Veatch, West Virginia

The pasture areas sprayed with a helicopter in 1966 to control brush were inspected again in July. Records were made of regrowth and pictures taken of the staked 1/100 acre plots. Small brush and briars were controlled. In many cases the thorne apple was resprouting indicating

that a repeat application of 2,4-D and 2,4,5-T should be made at least every third year. Tordon has proven quite effective but still has not been cleared for use in pastures. Weed control trials in corn were carried on at four locations in trials to test the possibility of using 1 lb of atrazine in combination with other herbicides to reduce the residue problem. The most prevalent weed in our trials this year was fall panicum. It was controlled best with a combination of atrazine and Lasso. Seeding trials with crownvetch indicated that 6 lb per acre of Eptam incorporated before seeding gave good weed control.

Title: WEED CONTROL IN CROWNVETCH

Leaders: D. L. Linscott and R. D. Hagin
USDA - ARS and Cornell University

In 1968, EPTC was applied at 4 lb/acre in 30 gpa of water in May to a Hudson silt loam soil and incorporated by cross tandem disking. Crownvetch was seeded at the rate of 4 lb/acre with a grain drill equipped with band seeding attachments. The resulting crownvetch stand was marginal. By spring of 1969, a considerable population of yellow rocket (Barbarea vulgaris L.) had developed. On April 30, 1969 the following treatments were applied: paraquat, dinoseb, 2,4-DB, bromacil, at 0, 1/2, 1, or 1 1/2 lb/acre and simazine at 0, 1, 2 or 4 lb/acre, all in 30 gpa water. At the time of spray application, yellow rocket was about 6 inches tall.

Of the chemicals used, paraquat was most successful in containing yellow rocket while damaging crownvetch but little. As a result of paraquat action in removing early competition, crownvetch was released and within 4 weeks had covered the plots. Few grasses or broadleaf weeds appeared in these paraquat-treated plots until midsummer.

Excellent general weed control was obtained from simazine or bromacil but vetch growth was severely retarded by both chemicals. However, at rates of 1 lb/acre and lower, vetch made rapid recovery after July 15, and remained essentially weed free during the season. These simazine- or bromacil-treated plots should produce seed in quantity during 1970.

Dinoseb and 2,4-DB treatments were completely unsatisfactory for controlling weeds. Further, of all the chemicals used 2,4-DB was most damaging to crownvetch. Over 85% of the vetch plants were killed with 1 1/2 lb/acre of 2,4-DB. Of the others, paraquat was the only one which resulted in significant increases in plant numbers over the check as determined by midseason count. Plant numbers in paraquat-treated plots were 70% greater than controls in this particular experiment.

Title: WEED CONTROL DURING ESTABLISHMENT OF CROWNVETCH (CORONILLA VARIA L.)

Leaders: D. L. Linscott and R. D. Hagin
USDA - ARS and Cornell University

In 1968, 24 different chemical treatments were evaluated for weed control potential and the most promising selected for further study in 1969. The 1968 studies indicated that crownvetch was tolerant of pre-emergence applications of S-ethyl-dipropylthiocarbamate (EPTC) or N-butyl-N-ethyl-a,a,a-trifluoro-2,6-dinitro-p-toluidine (benefin) followed by a postemergence application of 2-sec-butyl-4,6-dinitro-phenol (dinoseb). Postemergence treatments were necessary to control broad-leaf weeds sufficiently.

The following treatments were determined to be most satisfactory for overall weed control and for tolerance by crownvetch during 1969:
EPTC 4 lb/acre preplanting + dinoseb 0.5 lb/acre postemergence > EPTC 2 lb/acre + dinoseb 0.5 lb/acre > EPTC 2 lb/acre + DNBP 1 lb/acre > benefin 2 lb/acre + dinoseb 0.5 lb/acre > benefin 2 lb/acre + dinoseb 1 lb/acre. Best season long weed control was obtained with EPTC at 4 lb/acre + dinoseb at 1 lb/acre, however, vetch plant numbers were reduced considerably. Weed control in plots receiving preplanting and postemergence treatments was excellent until about mid-July, after which time a considerable population of annual broadleaf weeds developed. Vetch in treated plots made good growth in spite of late weed encroachment and probably will produce well in 1970.

Title: METHODS OF BANDING HERBICIDES FOR WEED CONTROL DURING ESTABLISHMENT OF CROWNVETCH

Leaders: D. L. Linscott and R. D. Hagin
USDA - ARS and Cornell University

In 1969 EPTC at 2 lb/acre or benefin at 1 lb/acre was applied and incorporated and Chemung crownvetch was seeded in rows 72 inches apart with a drill equipped with band seeding, band fertilizing attachments, and packing wheels. At drilling, simazine or bromacil at 1 or 2 lb/acre in 30 gpa of water was applied between the seeded row. In other words, a 14-inch band directly over the seeded row received benefin or EPTC and the remaining area between the rows (= 58 inches) received a simazine or bromacil application as well. Simazine and bromacil were applied in two ways, namely on the surface and incorporated. The spray boom was attached to either the front of the drill for incorporated treatments (incorporation accomplished by revolving disks of the drill) or to the rear of the drill behind the packing wheels for the surface treatments.

Crownvetch in all plots receiving overall treatments of 2 lb/acre or 1 lb/acre benefin plus bromacil or simazine at 1 lb/acre between the rows, established successfully. By September 15, the vetch was in blossom and covered from 24 to 36 inches of row. Crownvetch received 2 lb/acre bromacil which washed into the seeded row by heavy rain. At the 1 lb/acre rate damage was minimal and annual grass and broadleaf weed control was excellent throughout the season. This technique of applying preemergence herbicides overall, and banding persistent herbicides between the row seems to be very promising for commercial crownvetch seed production.

Title: CHICKWEED CONTROL IN ESTABLISHED DORMANT CROWNVETCH

Leader: J. V. Parochetti, Maryland

Winter weeds such as chickweed are a problem in dormant crownvetch. The objective of this experiment was to evaluate several herbicides for chickweed control in crownvetch.

An experiment in established dormant crownvetch was conducted at the Plant Research Farm, near Fairland, Md. Herbicides were applied March 6, 1969.

Chickweed control was recorded as an estimate of the percentage of ground not covered by chickweed. Crownvetch injury was rated on a scale of 0 to 100 with 10 equalling no effect on the crop and 100 equalling 100% destruction; a rating of 30 or higher was considered unacceptable injury.

All herbicides except dinoseb resulted in 100% chickweed control when observed on June 3, 1969. Slight crownvetch injury occurred when 1.6 lb/acre simazine and 2 lb/acre of RH 315 were used (see table page 58).

Title: CHICKWEED CONTROL IN DORMANT ALFALFA

Leader: J. V. Parochetti, Maryland

Chickweed is a major winter weed problem in alfalfa in Maryland. Chickweed growth can become so dense that proper cutting and field curing are not possible, thus lowering the quality of the resultant hay. Three experiments were conducted in three different years with various chemicals for the control of chickweed.

Chickweed control in established dormant crownvetch.

Treatment	Rate lb/acre	June 3, 1969	
		% Chickweed control	% Crownvetch injury
1. Control	--	0	0
2. Diuron (Karmex)	0.8	100	0
3. Diuron	1.6	100	0
4. Simazine	0.8	100	0
5. Simazine	1.6	100	6.6
6. GS 14254	0.8	100	0
7. GS 14254	1.6	100	0
8. Dichlobenil (Casoran)	1.0	100	0
9. Terbacil (Sinbar)	0.4	100	0
10. Terbacil	0.8	100	0
11. RH 315 (Kreb)	1.0	100	0
12. RH 315	2.0	100	3.3
13. Chloropropham (Chloro-IPC)	1.0	100	0
14. Dinoseb (DNBP)	2.0	87	0

Experimental work was conducted in dormant Williamsburg alfalfa and orchardgrass predominantly infested with common chickweed which had been established at least one full year. Herbicides impregnated on a fertilizer carrier and granular formulation were applied as the dry material.

Herbicides applied as a spray were simazine, GS 14254, diuron, chloropropham, dinoseb, dichlobenil, terbacil, and RH 315. Herbicides that were impregnated on fertilizer were simazine, GS 14254, diuron, and chloropropham. Treatments were applied February 28, 1969, near Wilson, Md. The soil was Hagerstown loam with 2.9% organic matter, 44% silt, 30% sand, and 26% clay. The experimental design was a randomized complete block with three replications. All plots received 724 lb/acre of 0-10-30 fertilizer.

Simazine and GS 14254 applied as a spray at 0.8 lb/acre resulted in excellent (90% or better) control of chickweed, whereas, inferior control resulted from 0.8 lb/acre of sprayed diuron. At 1.6 lb/acre, these three herbicides provided excellent chickweed control. Chickweed control resulting from simazine and GS 14254 impregnated on fertilizer at 0.8 lb/acre at the early date of observation April 19 was about 10% less than the 0.8 lb/acre spray application. However, at the late date of observation of the chickweed, the impregnated fertilizer applications were comparable to the sprayed applications. At 1.6 lb/acre

simazine and GS 14254 impregnated fertilizer application provided excellent chickweed control similar to the 1.6 lb/acre sprayed application. Diuron on fertilizer provided inferior chickweed control, probably due to the late application date of February 28.

The only significant increase from the check in alfalfa-grass yields was an increase from 0.8 lb/acre of simazine impregnated on fertilizer. At the 0.01 level of probability there were no differences from the check and further yields were not taken.

Terbacil at 0.4 lb/acre resulted in excellent chickweed control, but completely eliminated the orchardgrass. RH 315 at 2 lb/acre and chloropropham at 1 lb/acre effected similar chickweed control which increased from fair to excellent control from April 19 to the April 30 observation. At the rates studied, dinoseb and dichlobenil were not effective chickweed herbicides.

Title: NUTSEDGE CONTROL PRIOR TO THE SEEDING OF ALFALFA

Leaders: D. L. Linscott and R. D. Hagin, Cornell and CR-ARS-USDA

A Honeoye silt loam was prepared in early May 1969. Planting of Saranac alfalfa was delayed until after treatment of emerged yellow nutsedge (Cyperus esculentus L.) with paraquat at 1/2 or 1 lb/acre. Paraquat was applied in 30 gpa water plus 0.1% nonionic surfactant. Treatments were applied at the following stages of development of nutsedge: 2 to 3 inches (June 11), 6 to 8 inches (July 1), 10 to 14 inches (July 14). After spray treatment all plots were disked twice with a tandem disk. Plots were seeded with 8 lb/acre of alfalfa the day of spraying. In addition, a second series of plots, which had received paraquat at the date indicated, were disked again and seeded July 18. The dominant weed species was yellow nutsedge. However, some wild mustard, Brassica kaber (DC.) L. C. Wheeler, common lambsquarters (Chenopodium album L.), and common ragweed (Ambrosia artemisiifolia L.) infested the area. Annual grasses were present but in insignificant amounts. Results are indicated in the following table.

Para- quat lb/A	Nut- sedge stage (inches)	Date - 1969		Yield & composition (9/30/69)*				Plants/ meter row (9/3/69)*		
		Sprayed	Disked & seeded	Total lb/A	Alf. %	Sedge %	BLW %	Alf.	Sedge	BLW
0	2-3	6/11	6/11	931	43	49	8	8	34	6
1/2	"	"	"	987	42	47	11	7	35	8
1	"	"	"	1134	42	54	4	8	39	6
0	"	"	7/18	2201	85	10	5	19	16	4
1/2	"	"	"	2507	86	8	6	19	14	5
1	"	"	"	2169	86	8	6	19	14	5
0	6-8	7/1	7/1	1780	70	23	7	16	19	8
1/2	"	"	"	1867	83	12	5	15	18	7
1	"	"	"	2070	83	12	5	16	18	6
0	"	"	7/18	2328	93	4	3	21	11	5
1/2	"	"	"	2768	92	4	4	24	10	5
1	"	"	"	2360	92	3	5	21	8	4
0	10-14	7/14	7/14	1902	85	8	7	23	15	8
1/2	"	"	"	2117	87	4	9	22	10	8
1	"	"	"	2344	89	5	6	24	13	5
0	"	"	7/18	1831	85	6	9	20	11	8
1/2	"	"	"	2181	90	6	4	26	5	6
1	"	"	"	1982	90	4	4	26	8	4

* Alf. = alfalfa; sedge = yellow nutsedge; and BLW = broadleaf weeds.

Title: PROJECT NE-13 - MECHANICAL AND PHYSICAL PROPERTIES OF FORAGE
RELATED TO PROCESSING, PRESERVATION, AND UTILIZATION

Leader: D. R. Mears, Chairman, Regional Technical Committee

Cooperators: The Agricultural Experiment Stations of the 12 North-
eastern States and the Cooperative State Research Service,
USDA

Stiffness of the rind of corn increased from bottom to top. Whole
stalk bending displacement was found to obey the uniform beam canti-
lever beam equation.

An analysis of thin-layer drying based on simultaneous heat and mass
transfer has been applied to chopped alfalfa. The resulting model was
compared with thin-layer drying results for alfalfa. This mathematical

description of drying may serve as the basis for simulation models of drying systems. A program for prediction of moisture content and material temperature during thin-layer drying was developed to illustrate the technique.

A fluidization drying process has been modeled by similitude considering the Reynolds Group, to determine if the generation of a particular stage design is valid. Flow patterns and velocity divergence have been determined using time-lapse photography of suspended plastic particles in a thin, lighted plane. Velocity profiles at finite locations thus obtained indicate that no abnormalities or further corrective measures are needed. The study is a prelude to a high temperature fluidization process as a component of a forage field combine.

Tests have been conducted to determine the relationship between compressive stress and density for silage. In the density range normally encountered in silos, compressive stress is proportional to density raised to a constant exponent. The proportionality constant and the exponent have been related to moisture content for sorghum silage.

Evaluation of self-feeding silage has been continued in the new dairy barn.

The failure characteristics of cylindrical compacted chopped forage specimens subjected to normal compression stresses in two directions were investigated. Material variables included: moisture content, length of cut and density. Triaxial testing procedures were followed and failure conditions recorded on a plot of axial vs deformation. Using techniques developed from triaxial tests of soil samples, factors of forage cohesiveness and angle of internal friction plus known lateral loads were developed into shear failure equations.

The data are under analysis but it is expected that the influence of moisture content, length of cut and density on forage material strength will be revealed. Such information can be related to forage handling and storage and should provide basic information for design of machines and structures.

Filled Teflon die information was measured for pulsation during wafering and for permanent deformation and was found to be minor.

A series of runs was made without a die and using a long split after-cone for pressure control. It was found that there was much less control over the wafering process and the product than when a 3-inch to 2-inch reduction die was used.

The measurement, over a period of years, of insecticide degradation in wafers continues.

Sheep wafer-feeding trials indicate some lack of ability of the sheep to eat the wafers, both crushed and uncrushed. However, of what was eaten, intake of crushed was greater and faster.

USEFULNESS OF FINDINGS:

Knowledge of the mechanical properties of cornstalks should be of value to plant breeders and designers of harvesting machines.

The combined mathematical and experimental analyses of thin-layer drying is expected to serve as a basis for computer simulation of drying systems.

Verification of the design of a drying stage which can provide the velocity divergence requirements for particular forage or biological particles is a useful and necessary step in the system concept development for a high capacity dehydration process. The usefulness of these data will be embodied in the scale-up for a real process under consideration.

Also the flow visualization techniques developed are useful for flow analysis and direct measurement of velocity within nonuniform process chambers.

The laboratory data collected on the compressive behavior of forage are useful in understanding the behavior of silage under conditions of mass flow. The indication that there is a minimum compressive strength at about 40% moisture is significant.

The new dairy barn is enabling an evaluation to be made of a self-feeder silo as an integral part of a forage storage/feeding system. Preliminary observations of this system are encouraging.

Knowledge of the shear failure behavior of compacted chopped forage materials has practical value for designing silage unloading and handling equipment and perhaps storage structures as well. If minimum failure loads can be determined and related to material physical parameters then criteria for minimum power use and maximum handling efficiency become available.

The data produced relative to die versus die-less wafer extrusion as well as that relative to length of aftercone may be useful in design and development of field wafering machines as well as stationary waferers.

Title: PRE-DIE MANIPULATION, DIE DESIGN AND MATERIALS, AND POST-DIE TREATMENT IN HAY WAFERING

Leader: E. C. Schneider, Vermont

Filled Teflon die deformation was measured for pulsation during wafering and for permanent deformation and was found to be minor.

A series of runs was made without a die and using a long-split after-cone for pressure control. It was found that there is much less control over the wafering process and the product than when using a 3-inch to 2-inch reduction die.

The measurement, over a period of years, of insecticide degradation in wafers continues.

Sheep wafer-feeding trials indicate some lack of ability of the sheep to eat the wafers, both crushed and uncrushed. However, of what was eaten, intake of crushed was greater and in less time.

Title: QUANTITATIVE DETERMINATION OF HEAT AND MASS TRANSFER COEFFICIENTS OF FORAGE

Leader: R. J. Rowe, Maine

This project is a contributing project to NE-13, Studies of the Physical Properties, Behavior and Forms of Forage as Related to Engineering Application.

An analysis of rapid high temperature drying of alfalfa led to the development of a mathematical model for the prediction of temperature and moisture content during thin-layer drying.

Temperature effect on drying rate was handled by a substitute of variable technique. This procedure was used to remove the effect of temperature from experimental data and to predict drying as a function of time and material temperature.

Moisture loss and material temperature were previously measured for a series of 134 thin-layer samples of chopped alfalfa. Tests were conducted at air temperatures ranging from 130 to 210 F and at several levels of humidity.

Analysis of the experimental results indicated that the drying coefficient was an exponential function of the material temperature,

A set of prediction equations for particle temperature and moisture content were fitted to experimental data using a nonlinear least squares technique.

The application of these prediction equations to the simulation of thin-layer drying was illustrated by a computer program to generate moisture content and material temperature response curves for a thin- or fully-exposed layer in an air stream of constant temperature and humidity.

Section IV

Growth, Physiology, Metabolism of Herbicides, etc.

Title: SEASONAL VARIATIONS IN CARBOHYDRATE RESERVES IN SMOOTH BROMEGRASS

Leaders: W. G. Colby and Mack Drake, Massachusetts

Our 1968 report dealt with seasonal variations in soluble carbohydrate reserves in stands of smooth brome grass seeded in August 1967. The work was repeated on the same seeding in 1969. We were primarily interested in the role of rhizomes in reducing plant injury during the period of rapid growth in June. In 1968 rhizomes did not develop until heading growth stage. In 1969 rhizomes from the previous year's growth were present and many new rhizomes were again formed at the heading growth stage. Injury from cutting at early growth stage, however, was much less severe in 1969 than in 1968. Even granting that seasonal differences may be a factor, soluble reserve carbohydrates in established rhizomes appeared to play an important role as a source of reserve energy during the early growth stages.

Title: ELECTROPHORETIC STUDIES OF SOLUBLE PROTEINS IN ALFALFA

Leaders: W. F. Faw and G. A. Jung, West Virginia

The water soluble proteins of the crowns of winterhardy Vernal, Narragansett, Rhizoma, and Teton and nonhardy Caliverde, African, Hairy Peruvian and Arizona Common varieties were examined at different growth stages while the plants were in a nonhardened condition. The protein content was found to decrease during the first week after topgrowth removal but to increase from that time until seed was formed, at which time the tops were again removed. Changes in the total amount of protein detected on electrophoresis columns and the amounts detected on different regions of the column were related to physiological changes associated with growth and maturation and in some cases to genetic differences among varieties.

Vernal and Arizona Common plants were grown under three hardening environments and two environments not conducive to the development of cold hardiness. Proteins extracted from crown and root samples by water and nine buffered solutions were examined. Protein content decreased in this order: Vernal plants grown under the hardening environments, Arizona Common plants grown under the hardening environments, plants grown under environments not conducive to hardening. Varietal differences in the amount of protein extracted were significant with all but three of the extracting solutions.

When densitometer traces of the stained protein patterns were divided into 14 regions, the total increase in proteins with hardening was found to be a result of increases in many of these regions. The amount of protein detected in many of these regions was highly correlated with plant cold hardiness.

When Vernal and Arizona Common plants were given a foliar application of either guanine, cytosine, CCC, GA or distilled water (control) and hardened at day temperatures of 7 C, 13 C or 24 C the concentration of water soluble protein was found to be influenced most by variety, less by day temperature, and least by the chemical applications. Interactions involving the variety, day temperature, and chemical application influenced the total amount of protein detected and the amounts detected on many of the column regions. Although the amounts of protein detected on six of the 14 column regions examined were significantly correlated with the amount of topgrowth produced during hardening, none were better correlated with the amount of topgrowth than with the level of cold hardiness.

Title ENVIRONMENTAL STUDIES WITH PLANTS

Leaders: A. M. Decker and D. T. Hawes, Maryland

Replicated soil temperature field plots (ambient, 10 C, 21 C, 32 C) were used in studies involving three forage and four turf species. Temperature and plant response data have been collected but summarization has only started.

Forage species. Top growth, root growth, tiller development and plant reserves of timothy were highest at 10 C and lowest at 32 C with 21 C being slightly superior to ambient. Responses of red clover were similar to those for timothy except optimum soil temperature was 21 C rather than 10 C. Dollard red clover performed relatively better at the cool temperatures while MD-Syn 1 was much more tolerant of high soil temperatures.

Turf species. Top growth patterns of bentgrass, bluegrass and tall fescue were similar to those obtained for timothy. Bermudagrass made little top growth at 10 C and was extremely active at 32 C. Green bermuda turf was maintained into mid-December even with subfreezing temperatures for extended periods. This condition persisted for over a week after the temperature controls were turned off. Turf quality during the season was highest at 21 C for bentgrass, bluegrass, and tall fescue while bermuda was best at 32 C. Food reserves of all grasses were highest at 32 C.

Title: FACTORS AFFECTING COMPETITION BETWEEN GRASS PLANTS AND CLOVER SEEDLINGS

Leaders: C. F. Gross and R. R. Robinson, Pasture Laboratory

Recent solution culture studies in the greenhouse indicated that actively growing roots of established orchardgrass do not release substances in the nutrient solution that inhibit the growth of ladino clover seedlings provided competition for water, nutrients and light is controlled (1967, 1968 Annual Reports, p. 46 and 69, respectively). To substantiate this result in soil culture an experiment was conducted in the greenhouse during the spring of 1969 with ladino clover and orchardgrass using a 1:1 ratio by weight of a soil-sand mix in 1-gallon cartons with water, nutrients and light competition controlled. Five soil water levels were established with soil columns contained in metal cylinders resting in reservoir pans to give water tables at depths of 15, 35, and 55 cm, with or without additional surface watering. Five grass-clover management systems were employed: ladino seeded with established orchardgrass, and in monoculture (no previous grass crop);

ladino in monoculture in pots where previously grown grass was killed by cutting belowground; and ladino in monoculture in pots where grass was grown previously but before seeding the clover the grass tops were removed and the soil repotted leaving in, or removing, the grass roots. Dry weights of the clover plants and grass clippings after a 30-day growth period were obtained.

Ladino clover growth was good where the grass was killed and equivalent to 2/3 of the clover yield from pots without a previous grass crop ("true" monoculture). Where the grass and clover were grown in association ladino yields were low, attributed to an unfavorable soil structure rather than to any influence of the grass per se. Clover yields from pots where the soil was replaced either with or without the grass roots were equal to those from the "true" monoculture pots and probably reflect the improved soil structure created when the soil was repotted.

Soil water levels did not greatly influence ladino growth. Extra water added to the soil surface produced variable clover response. There were some indications that soil with a 55 cm water table was at too low, and soil having a 15 cm water table was at too high a moisture content for optimum clover growth.

Title: EFFECT OF CLIPPING GRASS AT DIFFERENT HEIGHTS ON CLOVER GROWTH

Leaders: C. F. Gross and R. R. Robinson, Pasture Laboratory

In another competition study to determine whether clipping the grass back to different heights influences clover seedling growth, two trials in sequence were completed during the summer of 1969 in a cooled greenhouse utilizing the 1-gallon association pots from the preceding water levels experiment plus new monoculture pots. Both trials had similar orchardgrass-clover management regimes in that the ladino was seeded in monoculture; with grass killed by cutting it belowground; and with grass clipped at 1 and 4 inches 2x/week. However, trial 1 also had a 2-inch clip that was replaced in the second trial with ladino seeded alone in pots where the grass tops and roots were removed and the soil repotted. The clover was grown for 5 weeks in each experiment and the dry weight of the ladino seedlings and grass clippings determined. Previous techniques that controlled light as a variable were used and pots were adequately fertilized to eliminate nutrient competition.

Clover yields tended to decrease as the height to which the grass was clipped increased. Ladino seeded in pots where the grass was killed, or where it was grown in monoculture produced variable clover yields. Although clover yields were generally higher where the ladino was grown alone than where the two species were together differences between yields were inconsistent. The erratic clover response obtained in the previous water levels experiment and the two grass clipping trials

could be involved with factors as the interval between the time the grass is killed and clover seeding occurs, and soil compaction that may restrict clover growth to the point where yield differences are masked.

Title: EFFECT OF GRASS MANAGEMENT AND SOIL WATER LEVELS ON CLOVER
 GROWTH IN A SOIL-PERLITE MIX

Leaders: C. F. Gross and R. R. Robinson, Pasture Laboratory

A greenhouse experiment was conducted in the winter of 1969 with ladino clover and orchardgrass in gallon pots employing 3 soil water levels and a soil-perlite 1:1 by volume mix to provide a nonrestrictive root growth medium to determine whether cutting vigorous grass back to different heights affects clover seedling growth. Plant competition for water, nutrients and light was controlled with techniques used previously. The crop management regimes imposed were: associations--clover seeded in grass clipped at 1 (severe), 2 (moderate), and 4 (light) -inch heights 2x/week; monoculture--clover seeded with grass that had been killed by cutting the leaves and crown belowground; in pots where the grass tops were removed, the roots cut in pieces and distributed throughout the soil mix and repotted; and ladino seeded alone. The soil for each management regime was maintained at 34 (optimum), 28 and 40% moisture. The clover was harvested 46 days after seeding and dry weights of the seedlings and grass clippings, determined.

Highest yields were obtained where the ladino was grown in monoculture. Growing the clover in association with the grass clipped at 1, 2, and 4-inch heights produced unthrifty clover growth. The clover was benefitted where the grass was killed before the ladino was seeded with yields intermediate between other monoculture and the association treatments.

Both species were only slightly responsive to soil water level. Although clover yields were similar where the ladino was grown with grass cut at the light, moderate, or severe clips at any moisture percentage the clover yields from the monoculture pots were more variable with some indication of plant moisture stress at the lowest (28%) soil water level. Clover was generally more responsive at 34%, and intermediate at 40%, soil moisture.

Poor clover growth in the association pots may be attributed to nutrient competition between the legume and grass, or to a factor present when the two species are grown together in soil but absent when they are grown in association in nutrient solution culture.

Title: THE EFFECT OF AMINE AND ESTER FORMULATIONS OF 2,4-DB ON ALFALFA

Leader: J. V. Parochetti, Maryland

The purpose and objective of this experiment was to determine the degree of alfalfa injury resulting from spraying dormant alfalfa with an amine and ester formulation of 2,4-DB.

An experiment was established on the Wilbur Martin Farm, near Wilson, Md. Two different formulations of 2,4-DB were applied to alfalfa. The two application times were February 19, 1969, when alfalfa was dormant, and April 23, 1969, when the alfalfa had several leaves.

The percentage of alfalfa injury was visually rated on April 19 and 30. The ratings were based on the percentage of foliage exhibiting epinasty or twisting.

The February 19 application of amine formulation of 2,4-DB caused severe alfalfa injury; whereas, the April 23 application of the amine formulation resulted in 2 and 17% alfalfa injury at the 1 and 2 lb/acre rates, respectively.

The ester formulation caused severe alfalfa injury applied at either date (see following table).

The effect of amine and ester formulations of 2,4-DB applied to alfalfa.

Treatment	Rate lb/A	Time of application	% Alfalfa injury	
			4/19	4/30
1. Control	--	--	0	0
2. 2,4-DB (amine)	1	2/19/69	67	58
3. 2,4-DB (amine)	2	"	95	83
4. 2,4-DB (ester)	1	"	89	72
5. 2,4-DB (ester)	2	"	97	85
6. 2,4-DB (amine)	1	4/23/69	--	2
7. 2,4-DB (amine)	2	"	--	17
8. 2,4-DB (ester)	1	"	--	66
9. 2,4-DB (ester)	2	"	--	100

Title: SYMBIOTIC NITROGEN FIXATION IN ALFALFA-ORCHARDGRASS
ASSOCIATIONS

Leaders: R. R. Robinson, R. R. Hill, Jr., and C. C. Berg
Pasture Laboratory

To ascertain the variability within alfalfa varieties and strains of the amount of fixed N released to the associated grass each of 8 alfalfa selections was grown with Pennlate orchardgrass in gallon pots containing soil high in all nutrients except N. The grass was also grown alone. The possibility of devising rapid, greenhouse procedures for evaluating the N-fixing efficiency of individual plants, progenies, and varieties of alfalfa was also investigated. The experiment was conducted in an "air-conditioned" (water-drip/fan evaporating system) greenhouse during the summer and fall of 1969. Plants were harvested six times, and total production of the alfalfa and orchardgrass was determined separately.

Results indicate that orchardgrass yields were similar whether the grass was grown in monoculture or in association with any one of the various alfalfa selections and imply little, if any, release of N to the orchardgrass by the alfalfa. This unexpected negative result may have been associated with soil temperatures above optimum for N fixation during the summer months and below optimum light intensity for plant growth during the fall.

Section V

Utilization, Nutritive Evaluation, Hay, Silage, etc.

Title: PROJECT NE-24 - THE NUTRITIVE EVALUATION OF FORAGES

Leader: A. M. Smith, Chairman, Regional Technical Committee

Cooperators: The Agricultural Experiment Stations of the 12 Northeastern States, the U.S. Regional Pasture Research Laboratory, the Dairy Cattle Research Branch, ARS, and the Cooperative State Research Service, USDA

The objectives of the NE-24 regional project are 1) to study basic factors controlling the intake and utilization of forage crops by ruminant animals, 2) to cooperate with plant breeders and agronomists in evaluating forage species and varieties by determining intake levels and the digestibility of energy and protein. Among the major factors shown to influence the intake and utilization of forage crops, contributing stations to NE-24 examined the following during 1969, a) growth stage and maturity, b) species and variety of forage, c) level and type of fertilization and herbicides, c) effects of chemical and physical composition of the diet.

The previously observed effects of a significant decline in the digestibility and level of intake of hay crops and pasture associated with increasing maturity in the first growth period were confirmed at several stations (Delaware, Mass., Maine, Maryland, New Hampshire, New Jersey, Pennsylvania, Rhode Island, West Virginia, and Dairy Cattle Research Branch).

New York reported that the intakes of digestible organic matter for ad libitum and restricted grazing under high and low stocking rates, respectively, were 62.2, 42.0, 67.9, and 39.5 g/MBS/day. West Virginia reported that in grazing ewes there were significant effects of year, trial, fertilizer treatment and state of ewe (dry or lactating) on DM intake and digestible DM intake. Also the use of rabbit data to predict digestibility data for the grazing sheep appeared to be questionable.

Comparisons were made of the relative digestibility and intake of legume forages compared to perennial and annual grasses (Maine) and of varieties within grass (Delaware, Maryland, New York, Pennsylvania, West Virginia) and legume species (Maryland, Pennsylvania, Dairy Cattle

Research Branch). Maryland released the new alfalfa variety, Team, which has some resistance to alfalfa weevil. The Dairy Cattle Research Branch (Utah data) stated that alfalfa yields of DM were considerably less in 1968 from the areas previously harvested four times vs three. Also slight but consistent differences have favored Ranger over DuPuits and Lahontan.

Several stations continued to determine the influence of fertilization on the quality of forage crops (Connecticut, Delaware, Massachusetts, Pennsylvania, Rhode Island, West Virginia). Increasing levels of N, and time of N application, were found to affect the composition and fermentation characteristics of timothy cut at different growth stages and preserved as silage (Mass.). Using different feeding procedures, Pennsylvania and Delaware noted an effect of N fertilization on the level of consumption of timothy and orchardgrass hays, respectively. The incorporation of micro elements in an NPK fertilizer, was found to influence the dry matter digestibility and intake of orchardgrass hays by sheep (West Virginia). Connecticut reported that the herbicide, simazine, and nitrogen fertilizer influenced DM and crude protein yields in reed canarygrass. High levels of simazine and nitrogen on the same plot tended to elevate nitrate. Delaware reported that potassium fertilization tended to increase voluntary feed intake by wethers but not digestibility.

Factors affecting intake and utilization of corn silage were examined at New Hampshire and New Jersey. New Jersey suggested that voluntary intake of corn silage may be limited by the form or amount of nitrogen supplement. The utilization of soluble nitrogen was less than an insoluble form in isonitrogenous mixtures. However, additional soluble nitrogen (unequal nitrogen mixtures with higher total nitrogen in the more soluble mixtures) utilized at a lower efficiency provided equal animal performance.

A new phase of work has been started in the study of effects of concentrate and nonnutritive-bulk supplements on forage utilization (New Hampshire, New Jersey, Pennsylvania, Vermont). Pennsylvania suggested for both ruminant and nonruminant animals that DE/ml continued to be a better means of predicting feed and energy intake than DE/g. Vermont reported the following: feeding sodium bicarbonate failed to reverse the rumination depression produced by feeding readily fermentable carbohydrate sources. Citrus pulp produced rumination in proportion to its CWC content but beet pulp stimulated much lower rumination times than would be predicted from its CWC content. Normal rumination was maintained by polypropylene fibers small enough to be regurgitated when fed in all concentrate ration normally producing no rumination. Polypropylene fibers too long to be regurgitated produced only long periods of intermittent liquid regurgitation with a similar concentrate ration. To completely reverse the diurnal rumination pattern it was found necessary to reverse both the light schedule and the feeding schedule.

USEFULNESS OF FINDINGS

Work being conducted on the effects of time of cutting, forage species and variety, rates of fertilization and method of conservation will assist the farmer and agronomist in obtaining optimum utilization of forage crops in the Northeast Region. A study of the interaction of forage feeding with concentrate supplementation will be of value in recommending management practices for several types of livestock enterprise. The development of effective laboratory techniques for the prediction of forage quality has been extremely valuable to the animal scientist and plant breeder in providing rapid screening methods for the selection and management of forage crops.

Title: THE EFFECT OF RETAINED FERMENTATION GASES ON THE PRESERVATION OF FORAGE AS SILAGE

Leaders: H. Fenner and W. G. Colby, Massachusetts

Pure stands of timothy (1967) and brome grass (1968) fertilized with 35, 70, 105 and 175 kg N/ha and cut at various stages of physiological maturity were conserved as silage in quart-sized glass containers. Simultaneously two different types of closures were used for preventing air to enter the silos. One type allowed by spring action the escape of excessively high pressure of accumulated fermentation gases; the second type of closure generally retained the formed gases in the containers. This resulted in qualitative and quantitative differences in composition of the recovered forage as silage.

The "silos" with the retained fermentation gases produced silages at lower losses of dry matter, crude protein, fat, N-free extracts and crude fiber, than the containers with a moderate gas pressure. With the exception of lactic acid, all products of silage fermentation were lower in the silages from the gas retaining containers. It is assumed that the CO₂, under pressure converted to the carbonic acid, had a nutrient conserving effect on the original forage components. Both the organic acids and the gaseous by-products, mainly CO₂ formed by the fermentation, have been utilized for the preservation of the forage.

Title: THE NUTRITIVE VALUE OF FORAGES

Leaders: J. L. Evans, Z. Nomani, and M. A. Graces, New Jersey

The voluntary intakes of urea-corn-silage supplemented with corn products or urea N and alfalfa hay supplemented with energy containing a low level of N from corn products or urea were evaluated in two trials. In addition, the utilization of ration N was determined.

In the corn silage trial, the apparent DDM for the three rations was 72%. The protein equivalent and soluble N (mostly from urea and percentage of total) were 13.6, 13.8 and 15.1%, and 25, 32 and 41% for rations 1, 2 and 3. Intake ($\text{g}/\text{wt}^{0.6}$), avg. daily gain (Kg) and retained N ($\text{g}/300 \text{ kg body weight}$) were 214, 225 and 229; 0.8, 0.5 and 1.0; and 42, 34 and 45, respectively. Because the utilization of soluble N was less (ration 2 vs 1), additional soluble N (ration 3) utilized at a lower level provided equal animal performance.

In the alfalfa trial, low-N grain with corn products or urea N were fed with alfalfa. Soluble N was higher in this trial than in trial 1. Apparent DDM, protein equivalent and intake ($\text{g}/\text{wt}^{0.6}$) were 66, 66 and 62%; 13.4, 12.7 and 16.7; and 209, 196 and 198 for corn-alfalfa, urea-alfalfa and all-alfalfa, respectively. Perhaps the all-alfalfa was deficient in energy, additional energy improved retained N (rations 1 and 2 vs 3), but intake was sluggish with the urea-grain-alfalfa (ration 2).

Title: THE NUTRITIVE EVALUATION OF FORAGES

Leaders: G. F. W. Haenlein, W. R. Kussow, M. R. Teel, W. H. Mitchell, and C. D. Passmore, Delaware

Daily variation in voluntary maximum consumption (basis of bodyweight^{.75}) of 1st cut orchardgrass hay (May 14 harvest) was compared in 2 trials of 63 and 83 days lengths, respectively, using 12 wethers each, by multiple correlation analysis with daily indoor maximum, minimum and average temperature, humidity, barometric pressure, several indices of the three parameters combined, the same parameters for the previous day, and the feed consumption of the previous day. Partial correlation coefficients were: previous day feed consumption (0.74, 0.69); maximum daily temperature (-.11, -.09); maximum daily humidity (-.04, -.06); minimum daily barometric pressure (0.16, 0.10); maximum temperature plus maximum humidity divided by minimum barometric pressure ($T + H/B$ index) (0.10, 0.20); previous day average temperature (-0.06, -0.09); previous day maximum humidity (0.18, 0.14); previous day minimum

barometric pressure (0.17, 0.17); previous day T + H/B index (0.11, 0.09). F-ratios for R^2 were significant for previous day feed consumption, maximum daily temperature, maximum daily humidity, minimum daily barometric pressure, T + H/B index. Dry matter contents of feces varied on 10 consecutive days for 24 wethers fed the same hays at constant intakes from 28.0-38.1%.

Experiments simulating different hays have been continued during the past year and feeding trials with wethers are in progress.

In a 3 x 3 x 3 factorial design the interaction of 3 levels of nitrogen fertilizer with 3 levels of potassium fertilizer on 3 varieties of orchardgrass hay (July 10 regrowth harvest) is being studied. Hay yields increased with nitrogen fertilization for 50, 100 and 200 lb N/acre: 2020, 2821 and 3500 lb hay/acre; potassium fertilization did not influence hay yields (0, 100 and 200 lb K₂O/acre: 2820, 2736 and 2756 lb hay/acre); varieties did not yield different amounts of hay: Common - 2697, S-37 - 2762, and Latar - 2870 lb hay/acre. Fertilization influenced the dry matter content of the grasses on the day of harvest: N₁-N₃: 70.8, 73.4, 73.5%; K₁-K₃: 68.4, 74.8, 74.6%. Hay analyses showed no clear trends in contents of Ca, K, Mg; but P decreased and N increased with N fertilization: 0.44-0.32%, 1.9-3.1%, respectively. Nine organic acids are being determined from acidified ethanol extracts of the hay samples by gas chromatography. Decreased amounts of malic acid were associated with higher K fertilization; increases in fumaric, malic, α -ketoglutaric, cis-aconitic, isocitric and citric acids appeared with higher N fertilization. Feeding trials using 4 wethers each over 21-day periods with the 27 lots of hay are in progress. Digestibilities of energy, protein and dry matter did not vary so far with K fertilization but voluntary feed intakes tend to increase. Varieties had no influence.

Title: INFLUENCE OF PHOTOPERIOD AND THERMOPERIOD ON TALL FESCUE
IN VITRO DIGESTIBILITY

Leader: D. W. Allinson, Connecticut (Storrs)

Kenwell and Kentucky 31 tall fescue were grown in growth chambers under the following environmental conditions: (a) 80 F day and 60 F night temperature with a 16-hr photoperiod, (b) 80 F day and 60 F night temperature with a 10-hr photoperiod, (c) 60 F day and 40 F night temperature with a 16-hr photoperiod, and (d) 60 F day and 40 F night temperature with a 10-hr photoperiod. Two harvests were taken, the first, after 8 weeks growth and the second, after 11 weeks growth. Tissues were dried, ground, and analyzed for in vitro dry matter digestibility (IVDMD), and acid-detergent fiber (ADF), acid-detergent lignin (ADL), cell wall constituents (CWC), and in vitro cellulose digestibility (IVCD).

Both long days and high temperatures significantly ($P < 0.01$) lowered IVDMD in both harvests. High temperatures significantly ($P < 0.05$) lowered IVCD compared to low temperatures. Generally both long days and high temperatures increased the percent ADF, cellulose, CWC, and hemicellulose contents of tissues compared to short days and low temperatures. There was no significant difference between the varieties for any of the measured parameters. In the first harvest the percent ADL was significantly ($P < 0.05$) lower for those tissues grown under the low temperature regime, though no such difference was evident in the second harvest.

Title: NUTRITIVE VALUE OF LIVESTOCK FEEDS PRESERVED AND STORED
AS SILAGE

Leaders: J. B. Washko and E. M. Kesler, Pennsylvania

Pa. corn hybrid 510 produced the highest dry matter yields for ensilage followed in turn by Sweet Sioux sorghum-sudangrass hybrid, Trudan 4 hybrid sudangrass and Piper sudangrass. When compared with corn the sorghum-sudangrass hybrid produced only 63.3% as much forage, the hybrid sudangrass only 56.08 and the open-pollinated Piper 50.3% as much forage. Silages from these summer annuals in 1968 were fed to lactating dairy cows with the following results: palatability and cow performance were highest for corn silage, followed, in order, by Sweet Sioux, Trudan 4 and Piper sudan. Due to inclement weather and machinery failure, only the Piper sudangrass and the corn crop harvested at 25.4 and 35.9% dry matter were ensiled in 1969 for feeding trials with lactating cows in 1970.

These results indicate that Pennsylvania livestock farmers should choose corn as their silage crop in preference to other summer annuals.

Title: BEEF CATTLE PERFORMANCE AS RELATED TO FORAGE

Leaders: L. L. Wilson, J. B. Washko, and A. L. Haskins, Pennsylvania

Data were collected on 80 steers and 94 heifers (13 sires). Sire effects were significant for tenderness, I. dorsi area, cutability, and weight and percentage of trimmed loin and round. Sire x sex interactions were nonsignificant except for 205-day weight. Data from 48 Angus-Holstein cows and calves in 2 x 2 x 2 factorial of 85 vs 115% NRC DE, large vs small cow, and bull vs heifer calves: 1) no DE x size interactions on milk traits or cow or calf weights, 2) no significance

of calf sex or body size on milk or weight traits, 3) milk production was 70% greater than previous reports with beef breeds. Two trials comparing the use of implants (24 mg DES and 120 mg testosterone) were conducted. Implanted Herefords gained 0.40 lb/day more ($P < .05$) with larger I. dorsi areas ($P < .05$) and lower grades than controls. Implanted Holstein steers gained 0.34 lb/day less but averaged greater for I. dorsi area and lower ($P < .05$) grades. Tall-growing perennial grasses (orchard and reed canary) furnished 3.96 tons DM and 156 days grazing/acre when fertilized with 100 lb N. Corresponding values were 2.57 tons, 113 days, and 3.0 tons, 176 days for Ky. bluegrass and Piper sudan, respectively.

Title: IN VITRO DIGESTIBILITY OF CROWN VETCH

Leader: T. A. Long, Pennsylvania

The Department of Agronomy supplied 44 samples which included Penngift and Chemung varieties of crownvetch and Viking trefoil. These samples represented first and second cuttings of the legumes grown at three levels of fertilization (see table footnote). The samples were harvested in the summer of 1968 from university experimental plots located in Somerset, Pa.

The estimated in vivo digestibility of the samples was determined using the Tilley and Terry method. These digestibility values are presented along with the crude protein content (determined by Kjeldahl method) in the following table.

Estimated in vivo digestibility values and total nitrogen contents of Penngift, Chemung, and Viking trefoil.

Fertilization level*	Penngift	Chemung	Viking trefoil
First cutting (6-16-68)			
None	60.33 - 14.33	63.34 - 17.10	58.49 - 13.07
Medium	60.40 - 13.22	63.18 - 17.30	57.74 - 11.67
High	61.87 - 12.97	62.87 - 16.58	59.00 - 14.13
Second cutting (9-5-68)			
None	62.38 - 18.94	68.01 - 20.50	61.15 - 14.35
Medium	62.71 - 18.71	62.57 - 17.86	56.64 - 13.19
High	60.35 - 18.57	61.80 - 17.19	60.89 - 12.94

* Fertilization levels included 0, 360, and 720 lb per acre of 0-20-20 (0% nitrogen, 20% of P_2O_5 , 20% of K_2O) at zero, medium, and high levels, respectively.

The in vitro digestibility values within cuttings show that Chemung had the highest, followed by Penngift and Viking trefoil, respectively. The level of fertilization (with 0-20-20) appeared to have little, if any, effect upon the digestibility of these plants. The level of total nitrogen was noticeably higher within varieties in the second cutting, but the effect of this higher nitrogen content upon digestibility was not apparent. In the first cutting the total nitrogen content of Chemung was appreciably higher than either Penngift or Viking trefoil. Penngift and Viking trefoil appeared to contain similar amounts of nitrogen at first cutting.

Title: THE NUTRITIVE EVALUATION OF CORN SILAGE

Leaders: N. F. Colovos, J. B. Holter, J. R. Mitchell, and H. A. Davis,
New Hampshire

Emphasis on corn silage research continues in the Northeast because corn silage has already become the number one forage for dairy cattle in this area of the country. There are still many questions to be answered as to the stage of maturity of the plant at harvest, how best to supplement it for protein and the effect of inclusion of other ingredients in the ration that has corn silage as the sole forage.

Corn plants were harvested for silage at four stages of ear maturity: milk (Sept 5-6), hard dough (Sept 17-19), late dent (Sept 24-28), and glazed-frosted (Oct 14). The resulting four silages were fed in equal DM quantities at a level in slight excess of intake, along with 1 kg supplement (protein, vitamins, minerals) daily, to four 450 kg dairy steers using a 4 x 4 Latin square design. Within this design a split plot arrangement was utilized whereby each of the above diets was fed with 2.7 kg rolled corn, daily, substituted for part of the silage on an equal energy basis. Each of the eight diets was compared using digestibility and complete energy and nitrogen balance trials.

The results show that net energy and TDN did not rank the four silages in the same order. Both traits contained substantial within-treatment variation, but treatment means were not greatly different.

The latest-cut silage was slightly higher in net energy, principally because of lower methane and heat increment energy losses. When rolled corn was substituted for part of each silage, the resulting diet (containing corn harvested in the glazed and frosted stage of maturity) was slightly superior in net energy per unit dry matter primarily because of lower heat increment and methane energy losses. Silage dry matter intake and fiber digestibility were depressed in the most mature silage. Since silage orts were greater on this silage, selective eating may have contributed to the slightly higher net energy value of the dry matter consumed.

Substituting some rolled corn in the diet generally increased the efficiency of energy utilization principally through increasing ration digestibility although it caused a decrease in fiber digestibility. No change was noted in percentage of gross energy lost in urine, methane or heat increment.

Title: THE NUTRITIVE EVALUATION OF CORN SILAGE

Leaders: N. F. Colovos, J. B. Holter, and H. A. Davis, New Hampshire

Corn plants were harvested for silage at four stages of ear maturity: milk (Sept 5-6), hard dough (Sept 17-19), dent (Sept 24-28), and glazed-frosted (Oct 14). The resulting four silages were fed at approximately 90% ad libitum levels, along with 1 kg supplement (protein, vitamins, minerals) daily, to four 450 kg dairy steers using a 4 x 4 Latin square design. Within this design a split plot arrangement was utilized whereby each of the above diets was fed with 2.7 kg rolled corn, daily, substituted for part of the silage on an equal energy basis. Each of the eight diets, was compared using digestibility and complete energy and nitrogen balance trials. Data from this experiment currently are being summarized and prepared for publication.

Title: PASTURE EVALUATION USING BEEF STEERS

Leader: A. M. Decker, Maryland

Midland bermudagrass pastures were sod seeded in the fall with a mixture of rye, wheat, and hairy vetch and fertilized with either 200 or 400 lb of N per acre in four equal split applications. These pastures were then grazed either continuously or rotationally. Stocking rates were the same at each nitrogen level and this was determined by the forage available on the rotation pastures. The experiment had two complete replications. The experimental pastures were grazed from April 4 through October 22, 1969.

At 400 lb N carrying capacity was 0.19 A.O. higher than at 200 lb N. Daily animal gains were also increased slightly with high nitrogen but increased beef production was only 20 lb. Animal production was similar at both types of grazing systems with continuous grazing being slightly more productive. Dry matter yields were similar for all pastures.

Title: THE NUTRITIVE EVALUATION OF FORAGES

Leaders: R. W. Hemken and A. M. Decker, Maryland

The alfalfa weevil resistant variety Team was compared in digestibility and intake trials with Williamsburg and Waterman and Loomis 303. The hays were harvested twice and will be compared again with two cuttings harvested in 1969. Digestion coefficients for dry matter, protein, energy, and fibrous components were not statistically significant. A small but statistically significant difference in intake did exist primarily due to a little lower intake with the Williamsburg variety (see table below).

Voluntary intake of three varieties of alfalfa hay.

Hay intake	Varieties			
	Williams- burg	WL 303	Team	SE
Trial I (1st cutting)*				
Percent of body weight	2.00	2.09	2.18	0.03 [†]
Kg/100 kg metabolic size	7.96	8.32	8.75	0.14 [‡]
Trial II (aftermath)				
Percent of body weight	2.21	2.10	2.33	0.04 [§]
Kg/100 kg metabolic size	8.99	8.48	9.28	0.08 [¶]

* Average of two separate periods of trial.

[†] Statistically significant ($P < 0.025$).

[‡] Statistically significant ($P < 0.005$).

[§] Statistically nonsignificant ($P > 0.10$).

[¶] Statistically significant ($P < 0.05$).

Sixteen Midland bermudagrass hays which had previously been studied in intake and digestibility studies were analyzed chemically with procedures as outlined by Van Soest. The combined predicted dry matter digestibility of these hays (representing 3 years, several stages of maturity, and several cuttings) resulted in a low correlation value $r = 0.36$. If only the last 2 years are used the correlation was above 0.9.

USEFULNESS OF FINDINGS:

On the basis of agronomic studies and the results of the animal trials reported above, Team has been released as a new alfalfa variety which has some resistance to alfalfa weevil.

Title: THE NUTRITIVE EVALUATION OF FORAGES

Leaders: J. G. Welch, A. M. Smith, and R. T. Wetherbee, Vermont

Feeding sodium bicarbonate failed to reverse the rumination depression produced by feeding readily fermentable carbohydrate sources. Citrus pulp produced rumination in proportion to its CWC content but beet pulp stimulated much lower rumination times than would be predicted from its CWC content. Feeding alfalfa pellets produced higher amounts of rumination from normal hay fed subsequent to the alfalfa feeding than did a simple fast, prior to the normal hay feeding. Normal rumination was maintained by polypropylene fibers small enough to be regurgitated when fed in all concentrate ration normally producing no rumination. Polypropylene fibers too long to be regurgitated produced only long periods of intermittent liquid regurgitation with a similar concentrate ration. To completely reverse the diurnal rumination pattern it was found necessary to reverse both the light schedule and the feeding schedule.

Application of findings. Intake of forages continues to be a most important aspect of forage utilization. The results of the rumination studies will be used in formulating feeding practices based on inducing the greatest rate of passage and forage intake potential.

Title: EFFECT OF NITROGEN FERTILIZATION AND PLANT MATURITY ON SILAGE FERMENTATION

Leaders: H. Fenner and W. G. Colby, Massachusetts

Pure stands of bromegrass treated with 4 levels of N 35, 70, 105, 175 kg/ha were cut at 5 stages of maturity and at 2 aftermaths and were preserved in quart-sized mason jars. After 90 days of storage at constant temperature (22 C) and subsequent maintenance at 4 C the forages were analyzed for changes and losses in nutrients and for fermentation products.

As reported last year for timothy grass (1968 Annual Report, p. 82), also bromegrass showed the same changes in plant composition due to

treatment. Concentration changes of fermentation products as affected by N-fertilization and maturity of the crop were not linear but almost persistently followed a curve-shaped pattern. Restricting the escape of fermentation gases, again resulted in lower dry matter losses due to fermentation.

USEFULNESS OF FINDINGS:

The expected results will allow an understanding of the interaction of crop management, yield and preservation of forage as silage.

Title: PERFORMANCE OF EWES ON NITROGEN FERTILIZED ORCHARDGRASS
 PASTURES

Leaders: R. L. Reid, G. A. Jung, R. Weiss, Amy J. Post, F. P. Horn,
 E. B. Kahle and G. E. Carlson, West Virginia

A study was begun in 1967 to determine the effect of fertilization (low, medium and high levels of nitrogen, and high nitrogen plus trace elements) on the composition of orchardgrass pasture, and on the nutritional and reproductive performance of ewes receiving the forage year-round for a 3-year period. Western ewe lambs gained most rapidly on the HN and HT treatments during the first grazing season. Period and fertilization effects were apparent on mineral, nitrogen and fiber components of herbage, but only period effects on blood mineral composition. Nitrate at potentially toxic levels was present in HN and HT treatments, but did not result in significantly increased blood methemoglobin, nitrate or ammonia levels in the ewes. Weight of lambs at birth in the first season did not differ between treatments, but histological and palpation examination showed a high incidence of thyroid abnormality in the lambs on the HN and HT treatments; thyroid wet weights were, for LN, 1.12 g; for MN, 0.87 g; for HN, 2.22 g; for HT, 6.31 g. Pasture evaluation trials during the second grazing season were run with dry and lactating ewes. A decline in DM digestibility and intake with advancing maturity of the herbage was observed; there were no significant effects of fertilizer on digestibility, but intake of HN and HT herbage was lower early in the season. In the second lamb crop, mortality in lambs and ewes was markedly higher in the LN and MN treatments than in HN and HT groups. There were treatment effects on lamb birth-weight; no difference in thyroid weight between treatments was observed, but thyroid histology was again abnormal.

Title: EFFECTS OF MICRO-ELEMENT FERTILIZATION ON NUTRITIVE QUALITY OF ORCHARDGRASS

Leaders: R. L. Reid, G. A. Jung, and Amy J. Post, West Virginia

A series of trials was carried out over a 4-year period to examine the influence of fertilization with individual elements (Mg, Cu, Zn, Mo, Co, S, Mn, B) and combinations of elements on the digestibility, intake, composition and palatability of different cuttings of orchardgrass hay for sheep. Initial trials showed an increase in DM digestibility of regrowth cuttings when treated with NPK + Mg or a combination of micro-elements (Zn, B, Cu, Mn, Mo) as compared with NPK alone. Intake and palatability (cafeteria) of first-cutting hay were higher for NPK alone than for NPK plus Mg or micro-elements. Subsequent trials at two levels of soil pH indicated a significant increase in the DM digestibility of first-cutting hays due to the incorporation of combined micro-elements (Zn, Cu, Mo, Co, S) in NPK fertilizer. In the last 2 years of the trials, significant differences in DM digestibility and intake within individual micro-element treatments were observed. Liming, in the year of application, resulted in a significant increased intake of orchardgrass under different fertilizer treatments by sheep, but had no effect on digestibility. No effects of liming were noted in subsequent years. The intake of regrowth hays in different years was found to be consistently higher than intake of first-cutting hays of equivalent DM digestibility. In 2 years, hays grown under different fertilization treatments were fed to lactating goats in mineral balance trials, and the milk was fed, alone or in combination with purified diets, to weanling rats. Differences in growth rate of the rats over a 3-week feeding period were observed.

Title: VITAMIN A STATUS OF EWES AND LAMBS ON FERTILIZED PASTURE

Leaders: F. P. Horn, R. L. Reid, and G. A. Jung, West Virginia

Groups of 18 Western ewe lambs were allocated to replicated orchardgrass (Potomac) pastures under 4 fertilization treatments 1) low nitrogen (LN), 56 kg N/ha; 2) medium nitrogen (MN) 168 kg N/ha; 3) high nitrogen (HN), 504 kg N/ha; 4) high nitrogen plus trace elements (HT), 504 kg N/ha + Zn, Cu, Mo, Co, S. Herbage carotene and nitrate concentrations, and blood carotene, blood vitamin A and liver (biopsy) vitamin A levels in 4 ewes per treatment were measured at monthly intervals during the grazing season and through the first lambing. Determinations were also made on lambs at birth and at slaughter after 4 months on pasture. Herbage carotene and nitrate levels significantly increased with increased levels of nitrogen application. There were significant period effects on blood carotene, blood vitamin A and liver vitamin A in the

ewes. The effect of fertilizer treatment on carotene and vitamin A values was not significant ($P > .05$); however, between animal variability was high and there was a definite trend for blood carotene, blood vitamin A and liver vitamin A to be higher in ewes grazing pastures treated with high levels of nitrogen. The ewes were fed hays produced under the same fertilizer treatments prior to lambing. Twin lambs taken before suckling had negligible vitamin A liver stores on any treatment, but the liver contained high levels of carotene. Lambs slaughtered after 4 months on pasture with their dams contained trace amounts of liver carotene; the mean level of liver vitamin A was 83.8 $\mu\text{g/g}$ liver. No effect of fertilizer treatment was noted on liver storage of vitamin A in 4-month-old lambs.

Title: MINERAL BALANCE OF LACTATING GOATS ON FERTILIZED HAYS

Leaders: K. Daniel, R. L. Reid, and G. A. Jung, West Virginia

Balance trials on calcium, magnesium, sodium, potassium and nitrogen were carried out on two cuttings of orchardgrass hay produced under different fertilization treatments (low nitrogen, 56 kg N/ha; medium nitrogen, 168 kg N/ha; high nitrogen, 504 kg N/ha + Zn, Cu, Mo, Co, S) and fed as the sole diet to lactating goats. Mean DM digestibility of the regrowth cuttings was higher ($P < .01$) than in the first growth, and fertilization had no effect on DM digestibility. Concentrations of Ca and Mg were lower, and of Na, K and N higher, in the regrowth hays. Increasing levels of N fertilization significantly increased the apparent availability (feed-feces) of Ca; mean availabilities on both cuttings were 22.2% on LN, 23.2% on MN, 25.7% on HN, and 32.3% on HT treatments. There was a mean positive retention of 0.6 Ca/day. Availability of Mg was higher on the regrowth hays, and increasing levels of N fertilization depressed Mg availability in both cuttings; mean availabilities were 33.9% on LN, 31.0% on MN, 11.8% on HN, and 13.5% on HT treatments. There was a mean positive retention of 0.29 g Mg/day. Sodium levels in the hays were generally low and retention negative; fertilization had little apparent effect on Na availability. Mean availability of potassium was approximately 90% for all treatments, and there was no apparent effect of cutting or fertilizer treatment on availability. Retentions were generally positive, at a mean value of 0.89 g/day. Apparent digestibility of N increased with level of N fertilization and retentions were significantly higher on the regrowth hays.

Title: EFFECTS OF NITROGEN FERTILIZATION ON THE THYROID FUNCTION
OF RATS FED 40% ORCHARDGRASS DIETS

Leaders: Chung Lee, R. Weiss and D. J. Horvath, West Virginia

A total of 108 weanling male rats was assigned to a 3 x 3 factorial experiment with 3 dietary iodine levels: 0.68 (high), 0.23 (medium), 0.08 ppm (low); and 3 diets: a basal diet, a high-N-hay diet containing 40% hay from a plot treated with 450 kg N/ha and a low-N-hay diet with 40% hay from a plot treated with 34 kg N/ha. An attempt was made to equalize many essential nutrients. After a 30-day feeding period, there were no significant differences in body weight gain among treatments. For rats fed the basal diet, the high-N-hay diet and the low-N-hay diet, respectively, average weights of the thyroid glands were 16.7, 22.0 and 19.0 mg; average heights of the thyroid epithelial cells were 3.9, 5.7 and 4.9 μ ; and average 24-hr post dose I^{131} thyroid levels were 15.2, 23.5 and 24.4% of dose. For groups receiving the high, medium and low dietary iodine, respectively, average weights of thyroid glands were 17.7, 17.4 and 22.6 mg; average heights of epithelial cells were 3.6, 4.2 and 6.7 μ ; and average I^{131} level in the thyroids were 9.9, 18.7 and 34.5% of the dose.

Title: REPORT OF STUDY OF VOLES FED DIETS CONTAINING 45 OR 60% HAY
FROM PLOTS FERTILIZED WITH LOW OR HIGH LEVELS OF N AND ZERO
OR 10 x NRC ADDED I

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Diets were formulated to determine if reproduction of voles could be achieved using forages at levels likely to be adequate for bioassay. Orchardgrass hay was harvested for high N and check Gilpin series plots at Reedsville, W. Va. in May 1968. The hay was ground through a 1/2 mm stainless screen in a Wiley mill, blended by rolling on a large plastic sheet and stored. Analysis was as follows:

Treatment	DM %	CP %	Ca %	P %	Mg %	ADF %
High N	96	19	.45	.18	.18	31
Check	96	10	.40	.18	.14	34

NRC rat requirements were used as initial guidelines for Ca (0.6%), P (0.05%) and I (0.015 mg/100 g diet). The value for supplemented I was set at 0.15 mg/100 g diet which is 10 x NRC. Organic P in casein

was ignored in establishing the level of supplemental P. Crude protein was made equivalent and, within forage level, acid detergent fiber (ADF) was made equivalent.

The following were analyzed statistically: percentage of I^{131} dose present in thyroids at sacrifice, initial weight (covariate), final weight, thyroid weight, occurrence of pregnancy (treated as covariate), dimensions of pouch and thyroid follicle cell height.

The effects of I supplementation were clear cut and highly significant for 3 measured variables. Forage level interacted with I in 3 instances, 2 of these being significant. The higher forage level reduced the effectiveness of supplemental I. Forage level had the negative effects on thyroid function, pouch diameter was not detected.

Occurrence of pregnancy was not associated with treatment and was not as common as had been hoped for purposes of bioassaying forage.

It is judged worth using the vole for assay of the forage from the small animal plots using supplemental Ca, P and I.

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